A MANUAL OF

ELEMENTARY FOREST ZOOLOGY

FOR INDIA

By E. P. STEBBING, F.L.S., F.Z.S., F.E.S.

Reprinted 1977

PERIODICAL EXPERTS BOOK AGENCY
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ELEMENTARY FOREST ZOOLOGY

FOR INDIA

By E. P. STEBBING, F.L.S., F.Z.S., F.E.S.

Imperial Forest Zoologist to the Government of India. Author of "Injurious Insects of Indian Forests," "The Insect World in an Indian Forest and how to study it," "Departmental Notes on Insects that affect Forestry," "Insect Life in India," etc.

CALCUTTA
SUPERINTENDENT GOVERNMENT PRINTING, INDIA
1908

Agents for the sale of Books published by the Superintendent of Government Printing, India, Calcutta.

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E. A. Arnold, 41 & 43, Maddox Street, Bond Street, W.

Constable & Co., 10, Orange Street, Leicester Square, W. C.

Bernard Quaritch, 11, Grafton Street, New Bond Street, W.

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PREFACE.

IN presenting this work on Indian Forest Zoology to the public I would invite attention to the fact that it has been primarily drawn up as a Manual for the use of the students at the Imperial Forest College at Dehra Dun, India.

It is claimed for the work however that, in the absence of any tex books of the kind entirely devoted to Indian Zoology, it will have a wider field and be to some extent useful in Agricultural and other colleges throughout the country.

The author is also in hopes that it will be found suitable as a text book, or supplementary text book, for use by the Indian Forest Probationers at the University of Oxford.

The arrangement of the work has been the outcome of careful thought, and whilst it may meet with valid and welcome criticism it should be borne in mind that the prime idea underlying the book was the necessity of keeping it purely Indian so far as was practicable. This has been found wholly possible in dealing with the most important portion, the *Insecta*. It is not too much to say that seven years ago it would have been quite impossible to write this part, about three-fifths of the whole book, as at present framed. That it has become feasible has been solely due to the enlighted action of the Government of India in creating in January 1901 the temporary appointment of Forest Entomologist; which post has now, owing to the indefatigable exertions of the Inspector General of Forests, Mr. Eardley-Wilmot, in bringing into being the Imperial Forest Research Institute, become merged into the permanent appointment of Imperial Forest Zoologist. With the creation of this post considerable progress has been made in the knowledge of the insect pests of our Indian Forests.

In order to keep the book within convenient dimensions it has been found desirable to print in small type descriptions of the life histories of the various animals given as examples of particular families. It

should be remembered however, that these portions are by no means the least important sections of the work.

My thanks are due to Lieutenant-Colonel A. Alcock, I.M.S., C.I.E., F.R.S., late Superintendent, Indian Museum, who, a few years ago, aided me in laying down roughly the scope of the Manual; from which basis experience has pointed out but slight deviations.

To Mr. A. E. Shipley, F.R.S., Professor of Zoology, Cambridge University, and Mr. E. R. D. Sewell, M.A., of St. Bartholomew's College, Cambridge, my thanks are due for their kind aid in reading over the proofs of the Introduction and Chapter I; also to the late lamented Dr. W. F. Blanford, F.R.S., C.I.E., for reading through the proofs of the portion of the work devoted to the *Vertebrata* and for giving me much kindly advice.

In the preparation of the Manual the following works of reference have been consulted:—Professor H. A. Nicholson's *Introductory Text Book of Zoology* and *Text Book of Zoology;* Professor T. Jeffery Parker's *Lessons in Elementary Biology;* Professor T. H. Huxley's *Lessons in Elementary Physiology;* Mr. J. E. V. Boas' *Text Book of Zoology;* Dr. Ritzema Bos' *Agricultural Zoology; The Cambridge Natural History Series*, especially Dr. Sharp's Volumes on the *Insecta;* The Volumes of the *Fauna of British India* Series and finally the *Journals of the Asiatic Society of Bengal* and the *Bombay Natural History Society.*

On the subject of the illustrations a word should be said. Illustrating works of this nature in India is always a difficulty, and the question of expense invariably comes to the front, since it is as desirable as it is imperative to keep the cost of the work within the purchasing power of those who will have to use it. My thanks are due to Major E. H. de V. Atkinson, R.E., Principal, Rurki Engineering College, and his assistants for the manner in which they have coped with a difficult task.

With regard to the illustrations themselves; a few are copied from the text books detailed above, and I wish here to suitably acknowledge their use.

For a few others I have to acknowledge my indebtedness to *Indian Museum Notes* and to the publications of the Agricultural Entomologist to the Government of India.

The illustrations of the portions of the work devoted to the *Insecta* are mostly original. For those in the section devoted to the *Vertebrata* I am indebted to the Secretary of State for India in Council who kindly granted me the use of the process blocks of portions of the *Fauna of British India*.

E. P. STEBBING.

Dehra Dun, 1907.

CONTENTS.

ERRATA.

Introduction, page xxi, line 13.—For "indentical" ***read*** "identical".

Introduction, page xxi, footnote.—For "BLANDFORD" ***read*** "BLANFORD".

Page 8, line 37.—For "per acre passes" ***read*** "per acre per year passes".

Page 15, footnote.—For "that species greatly reduced in Arthropods" ***read*** "that being greatly reduced in Arthropods".

Page 31, line 25.—For "The species existing" ***read*** "The number of species existing".

Page 43, line 22, and footnote.—Omit †.

Plate XV, Fig 72.—For "a, worker; b, soldier; c, larva of winged forms; d, young queen; e, female or queen with swollen" ***read*** "a, worker (to right) and soldier; b, larvæ of winged forms; d, young queen; e, female or queen with swollen, etc."

Page 48, line 18.—For "fig. 75 a, b, c," ***read*** "fig. 75 a, b".

Page 50, line 14, (and Index).—For "*Neurobosis*" ***read*** "***Neurobasis***".

Page 59, line 23.—For "Families ***Lymantria*** and ***Dasychira***" ***read*** "genera ***Lymantria*** and ***Dasychira***".

Page 59, line 26.—For "Chalcid pest" ***read*** "Chalcid fly".

Page 62, line 28.—For "page 71" ***read*** "page 69".

Page 70, line 33.—For "image" ***read*** "imago".

Page 71, line 8.—For "*Vespa valutina*" ***read*** "Vespa velutina".

Page 72, line 6.—For "construction" ***read*** "constriction".

Plate XXIV, Fig. 132c.—For "Sphenoptera gossypii" read "Capnodis miliaris".

Page 82, line 39.—For "Casarina" *read* "Casuarina".

Page 82, line 42.—For "Xylotrnpes" read "Xyloirupes".

Page 84, line 24.—For "Psendosphinix" *read* "Psendosphinx".

Page 94, line 16.—For "Capnodis sp." *read "Capnodis miliaris".*

Page 99, line 39.—For "Fig. 196, a, b, c, shows the larva" *read* "Fig. 196, a, b, c, d, shows the eggs, larva".

Page 100, line 17.—For "Fig. 200 a, b, shows the larva and beetle infest" *read* "Fig. 200 shows the beetle, infests".

Page 101, footnote, line 4.—For "intended" *read* "untended".

Page 104, line 23.—For "Fig. 211 b" read "Fig. 211 II".

Page 104, line 29.—For "best" *read* "bast".

Plate XLII A, Fig. 219.—For "Solcytus" *read* "Scolytus"

Page 109, line 22.—For "Fig. 222 a, b, c, shows the larva pupa and" *read* "Fig. 222 a, b, shows the larva and".

Page 110, line 34.—For "Fig. 288. a, b, c," *read* "Fig. 228 a, b, c,".

Page 112, line 32.—For "Fig. 235 a, b, shows the larva and beetle, bores into Shorea talurae" *read* "Fig. 235 shows the beetle, bores into Shorea talura".

Plate LVIII, Fig. 269.—For "Paliga damastesalis" read "Pyrausta machoeralis"

Page 135, line 4 (and Index).—For "Cosmia othreimargo" read "Cosmia ochreimargo."

Page 136, line 41.—For " and a cocoon " *read* " , the larva."

Page 137, line 14.—For " sometimes in autumn " *read* " some time in the autumn. "

Page 138, marginal note.—For " *Eucosmo* sp.' ad " *Eucosma* sp."

Page 138, line 14.—For " parting and forming " *read* " parting, and forms".

Page 146, line 2.—For " Simuludea " *read* " Simuliidae."

Page 158, line 22.—For " shows the young larva " *read* " shows a full grown empty larval skin ".

Page 165, line 8.—For " male " *read* " female ".

Page 171, line 27.—For " vetebral " *read* " vertebral ".

Plate LXXIX, Fig. 325.—For " common House Gecks " *read* " common House Gecko ".

Page 190, line 9.—For " is the only order which " *read* " is the only sub-class which ".

Page 205, line 29.—For " Viviporous " *read* " Viviparous ".

Page 206, line 10.—For " is important " *read* " is unimportant ".

Plate CX, Fig. 404.—For " *Arctomys cauaatus* " *read* " *Arctomys caudatus* ".

Page 226, line 8.—For " Tapaiidae " *read* " Tupaiidae ".

INDEX.

For " Basilianus andamanenis " *read* " Basilianus andamanensis ".

For " *Nemathelmirthes* " *read* " *Nemathelminthes* ".

For " Platypodyoe, grub of " *read* " Platypodœ, grub of ".

For " Rhyssas " *read* " Rhyssas sp.".

For " Trombidiidii " *read* " Trombidiidae ".

CALCUTTA: PRINTED BY SUPDT. GOVT. PRINTING, INDIA, 8, HASTINGS STREET.

INTRODUCTION.

THE THREE KINGDOMS OF NATURE.

1. Definition of Biology and Zoology.

ALL natural objects may be roughly divided into three groups constituting the so-called Mineral, Animal, and Vegetable Kingdoms.

The objects comprised in the Mineral Kingdom are all devoid of life and have the following characters:—They have a simple chemical composition (ex. native gold) or, if combined, the compounds are simple, consisting of two or more elements (ex. common salt, limestone, felspar, etc.); they are *homogeneous*, *i.e.*, the particles of which they consist have no definite relations to one another; their form is either altogether indefinite ('amorphous') or, if definite, they are crystalline, when they assume regular forms bounded by plane surfaces and straight lines; when they increase in size as crystals may do, the increase (called 'accretion') is produced simply by the addition of particles from the outside.

All bodies having the above characteristics belong to the Mineral Kingdom, and are treated of by the Sciences of Geology, Mineralogy, Chemistry, and Physics.

It may be mentioned that "fossils" or petrifactions are mineral bodies which owe their existence and shape to living beings which existed at former periods in the history of the earth. For this reason, fossils, though they are composed of mineral matter, cannot be considered as properly belonging to the Mineral Kingdom.

Having seen how to classify objects belonging to the Mineral Kingdom, we have now to consider the differences between the latter kingdom and the Animal and Vegetable Kingdoms. As a first definition it may be said that all the objects belonging to these two latter kingdoms possess what is called 'life.' They are composed of few chemical elements, carbon, hydrogen, oxygen, and nitrogen amongst others, and these elements are combined to form

complex organic compounds, which always contain a large proportion of water, are very unstable, and undergo decomposition easily; they are *heterogeneous*, *i.e.*, the parts of which they consist have usually more or less definite relations to one another, these parts being called 'organs' and the objects possessing them are said to be 'organised,' their form is always more or less definite with concave or convex surfaces, and bounded by curved lines; when they increase in size or "grow" as we call it, they do so by taking in foreign matter into their interior and assimilating it there; lastly, they always pass through certain periodic changes in a definite and discoverable manner—these changes constituting the life-history or life-cycle.

All objects, then, which fulfil these conditions, are said to be alive, and they all belong to either the Animal or Vegetable Kingdom. The study of all living objects, whether animal or vegetable, is called by the general name of BIOLOGY (Gr. *bios*, life; *logos*, discourse). As, however, all living objects belong to one of the two kingdoms, Animal or Vegetable, so Biology is divided into the two sciences of BOTANY treating of Plants, and ZOOLOGY (Gr. *zoön*, animal; *logos*, discourse) which treats of Animals.

2. *Difference between Animals and Plants.*

It now becomes necessary to consider the differences which exist between Animals and Plants and which enables us to split them up into the two sciences of Zoology and Botany. Originally it was believed that nothing could be easier than to determine the animal or vegetable nature of an organism. This is essentially true when we are considering the higher members of the two kingdoms. The higher animals are readily separated from the higher plants by the possession of a distinct nervous system, in being able to move about from place to place and in possessing an internal cavity fitted for the reception and digestion of solid food. The higher plants, on the other hand, possess no nervous system or organs of sense, are incapable of voluntary changes of place, and are not provided with any definite internal cavity; their food being wholly fluid or gaseous.

The lower animals (*Protozoa*), however, cannot be separated in many cases from the lower plants (*Protophyta*) by these distinctions, since many of the former have no digestive cavity, and are destitute

of a differentiated nervous system, and many of the latter possess the power cf active locomotion.

One of the most reliable of all the tests by which an animal may be separated from a plant is to be found in the *nature of the food* and the products which are formed out of the food within the body.

The differences between animals and plants in this respect may be stated as follows :—

1. Plants live upon purely inorganic substances, such as water, carbonic acid, and ammonia, and they have the power of making out of these true organic substances, such as starch, cellulose, sugar, etc. Plants, therefore, take as food very simple bodies and manufacture them into much more complex substances, so that plants are the great producers or manufacturers in nature.

2. All plants, which contain green colouring matter (chlorophyll), in the process of digestion break up carbonic acid into the two elements of which it is composed, namely, carbon and oxygen, keeping the carbon and setting free the oxygen. As carbonic acid always occurs in the atmosphere in small quantities, the result of this is that plants remove carbonic acid from the atmosphere and give out oxygen.

3. Animals, on the other hand, have no power of living on inorganic matters, such as water, carbonic acid, and ammonia. On the contrary animals require to be supplied with ready-made organic compounds if their existence is to be maintained. These they can only get in the first place from plants and therefore animals are all dependent upon plants for food, either directly or indirectly. Animals, therefore, differ from plants in requiring as food complex organic bodies which they ultimately reduce to very much simpler inorganic bodies. Whilst plants, then, are the great manufacturers in nature, animals are the great consumers. Another distinction arising from the nature of their food is, that whilst green plants in sunlight decompose carbonic acid, keeping the carbon and setting free the oxygen, animals absorb oxygen and give out carbonic acid, so that their action in the atmosphere is the reverse of plants. It has already been stated that amongst the lower organisms on both sides we have exceptions.

We may summarise the above by saying that plant protoplasm can be manufactured *direct* from the Mineral Kingdom. Animal

protoplasm can only be manufactured from plants directly as in the case of herbivorous animals, indirectly as in the case of carnivorous animals.

STUDY OF THE STRUCTURE AND VITAL PHENOMENA OF ANIMALS.

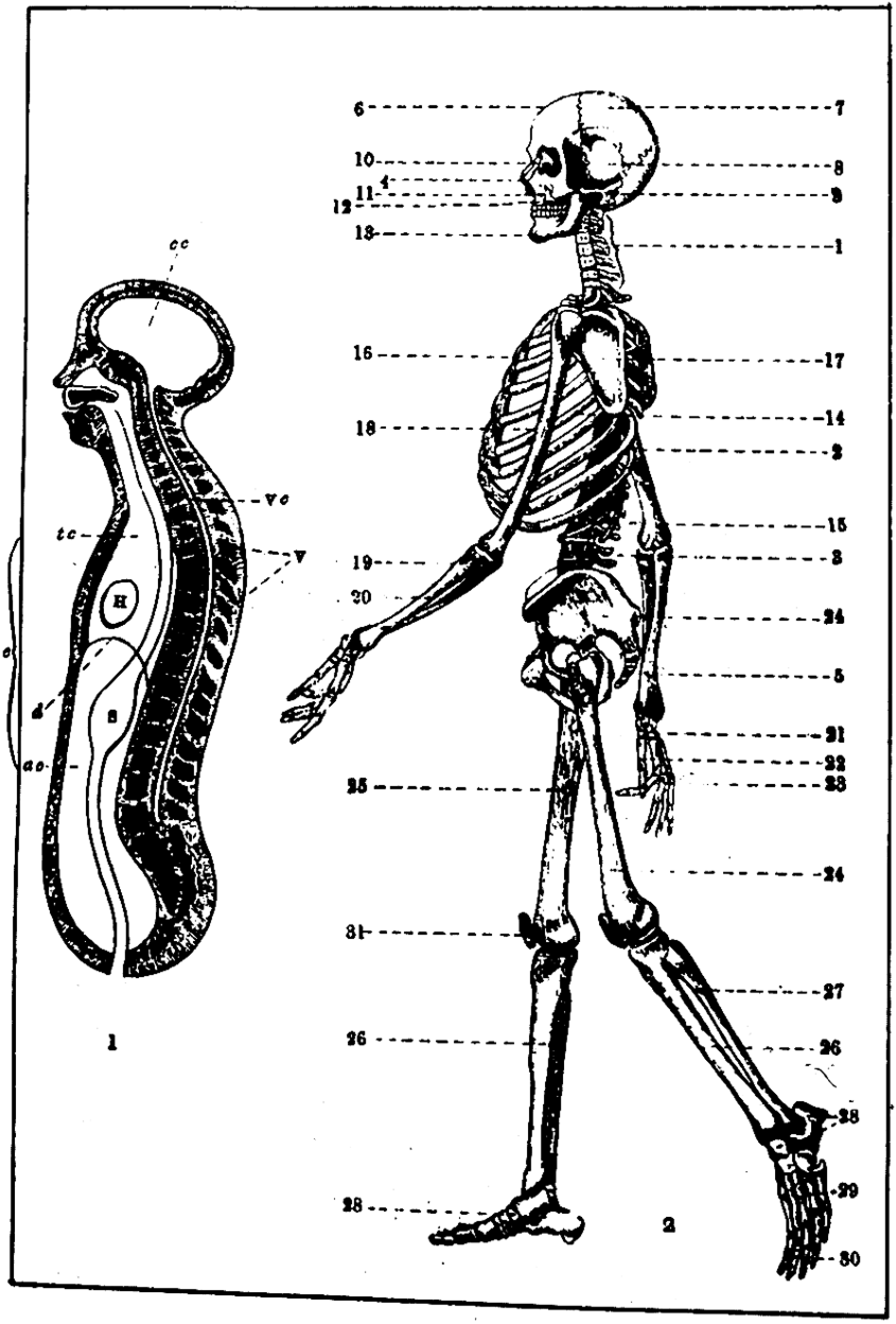
Before proceeding to a consideration of the general division of the Animal Kingdom, we will examine the structure of the highest forms of animal life (mammalia) and make a rough study of the human body and the bodies of mammals, examining the form of the body, its covering, skeleton, digestive, respiratory, circulatory, excretory, and nervous systems, sense organs, muscles and flesh, and reproductive system.

1. Form of the Body.

In the Mammalia the body can be obviously divided into three regions, *Head* and *Neck*, *Trunk* and *Tail*, *Limbs*. In the head the brain-case or cranium is distinguishable from the FACE. The trunk is naturally divided into the chest or *thorax* and the belly or *abdomen*. Of the limbs there are two pairs, the upper, or *arms*, and the lower, or *legs*, and legs and arms are again sub-divided by their joints into parts which obviously exhibit a rough correspondence—*thigh* and *upper arm*, *leg* and *forearm*, *ankle* and *wrist*, *fingers* and *toes* plainly answering to one another. And the two last in fact are so similar that they receive the name of DIGITS while the several joints of the fingers and toes are called PHALANGES (*see* figs. 1 and 2).

The whole body thus composed (without the organs which fill the cavities of the trunk) is seen to be bilaterally-symmetrical; that is to say, if it were split lengthways by a great knife, made to pass along the middle line of both the dorsal and ventral (or back and front) aspects, the two halves would almost exactly resemble one another as an object resembles its reflexion in a mirror.

The interior of the trunk is mainly occupied by a large chamber which is subdivided into the two subordinate cavities of the thorax and abdomen by a remarkable partly-muscular and partly-membranous partition, called the *midriff* or diaphragm. The alimentary canal (digestive system) traverses these cavities from end to end (fig. 1),



1. Longitudinal section of the human body. *cc*, cranial cavity; *bc*, body cavity; *tc*, thoracic cavity; *ac*, abdominal cavity; *d*, diaphragm; H, heart; S, stomach; V, vertebræ; V*c*, vertebral canal.

2. The Human Skeleton. (After Ritz. Bos.)

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piercing the diaphragm, as do also the main blood-vessels of the trunk and hind limb and the gangliated cords of the sympathetic nervous system.

The abdomen contains in addition to these parts the two KIDNEYS, one placed near each side of the vertebral column and connected each by a tube, the URETER, to a muscular bag, the BLADDER, lying at the posterior end of the abdomen: the LIVER, the PANCREAS, and the SPLEEN. The thorax incloses, besides its segment of the alimentary canal, the HEART and the two LUNGS. The latter are placed one on each side of the heart which lies nearly in the middle of the thorax. The two cavities are bounded behind by the back bone (vertebral column) which is made up of many vertebræ. The latter surrounds the dorsal cavity, called the vertebral or spinal canal.

The uppermost vertebra supports anteriorly a continuous mass of bone, which extends throughout the whole length of the skull and separates the Cranial from the Facial part. The Cranial Cavity becomes continuous through a large aperture—the foramen magnum—with the vertebral canal. The former encloses the Brain, the latter the spinal cord; these two parts, being continuous with one another through the foramen magnum, constitute the cerebro-spinal or central nervous system. The Facial part of the skull, with which we include the lower jaw or mandible, surrounds the anterior portion of the alimentary canal—the mouth—and serves to carry the teeth. The bones of this part of the skull are so arranged that they enclose a number of chambers or cavities which lodge and protect the organs of sight (the orbits), 2(10), and smell (the nasal cavities), 2(4).

The limbs, which are used for locomotion, contain no such chambers as are found in the body and the head; with the exception of some branching tubes, called blood-vessels which of course occur all over the body, they are solid or semi-solid throughout.

2. *Covering of the Body.*

The outer covering of members of the Animal Kingdom varies. In the invertebrate group of the Arthropoda the body covering consists of a hardened substance called CHITIN. Insects have their outer surfaces covered with this material. In the Mollusca, on the other hand, the outer covering is a SHELL as seen in a snail. Amongst

vertebrate animals, some reptiles and fish have scales, whilst the frog has usually a soft NAKED SKIN. In birds, again, the body is covered with FEATHERS, these being replaced in mammals by HAIR.

The skin or INTEGUMENT which underlies this covering, consists of two layers: a superficial which is, in mammals, constantly being shed in the form of powder, scales, etc., known as the EPIDERMIS; and a deep, the DERMIS consisting of connective tissue plentifully supplied with blood-vessels. Both Epidermis and Dermis are well-supplied with nerves, but it is only when the Dermis is injured that we get bleeding. Some distance within the margin of the apertures of the body, the skin becomes continuous with the mucous membrane, lining the various viscera such as the alimentary canal. This membrane presents a superficial resemblance to the skin, being also composed of two layers – a supporting layer of vascular connective tissue and a layer of epithelial cells next the lumen. Developmentally, however, it is quite distinct from it.

3. Connective Tissue, Muscles (Flesh).

The dermis and the deep fibrous layer containing blood-vessels which answers to it in the mucous membranes are chiefly made up of a delicate, elastic, fibrous network. This is called CONNECTIVE TISSUE because it is the great connecting medium by which the different parts of the body are held together. Thus it passes from the dermis between all the other organs ensheathing the muscles, coating the bones and cartilages, and eventually reaching and entering into the mucous membranes. Connective tissue varies very much in character: in some places being very soft and tender, at others—as in the tendons and ligaments which are almost wholly composed of it—attaining great strength and density.

The bones are usually surrounded by FLESH. This consists of a number of muscles, which are separated off from one another by septa of connective tissue. Each muscle is composed of a number of muscle fibres, all arranged so that they lie in the direction of the line of action of the muscle. Each of the fibres possesses the power of contraction and thus tend to approximate their two extremities, becoming shorter and thicker. The contraction of the muscles determines the various movements of the different parts of the body.

Some muscles are fixed by their ends to various parts of the body which they move by their contraction. If the upper arm of a man be stretched out and tightly grasped as the forearm is bent up, a great soft mass which lies at the forepart of the upper arm will be felt to swell, harden, and become prominent. As the arm is again extended the swelling and hardness vanish (*cf.* fig. 4). On removing the skin the body which thus changes its configuration is found to be a mass of red FLESH sheathed in connective tissue. The sheath is continued at each end into a tendon, by which the muscle is attached, on the one hand, to the shoulder-bone, and, on the other, to one of the bones of the forearm. This mass of flesh is the MUSCLE, called biceps. It is by reason of the property of contraction that muscular tissue becomes the great motor agent of the body; the muscles being so disposed between the systems of levers (bones) which support the body that their contraction necessitates the motion of one lever upon another.

There are other muscles which surround a cavity, and by their contraction propel the liquid or solid substances found in their cavity. The heart, for example, is a large muscle of this kind, serving to propel the blood, while the hollow muscular coat of the gut moves on the contained food.

4. The Skeleton.

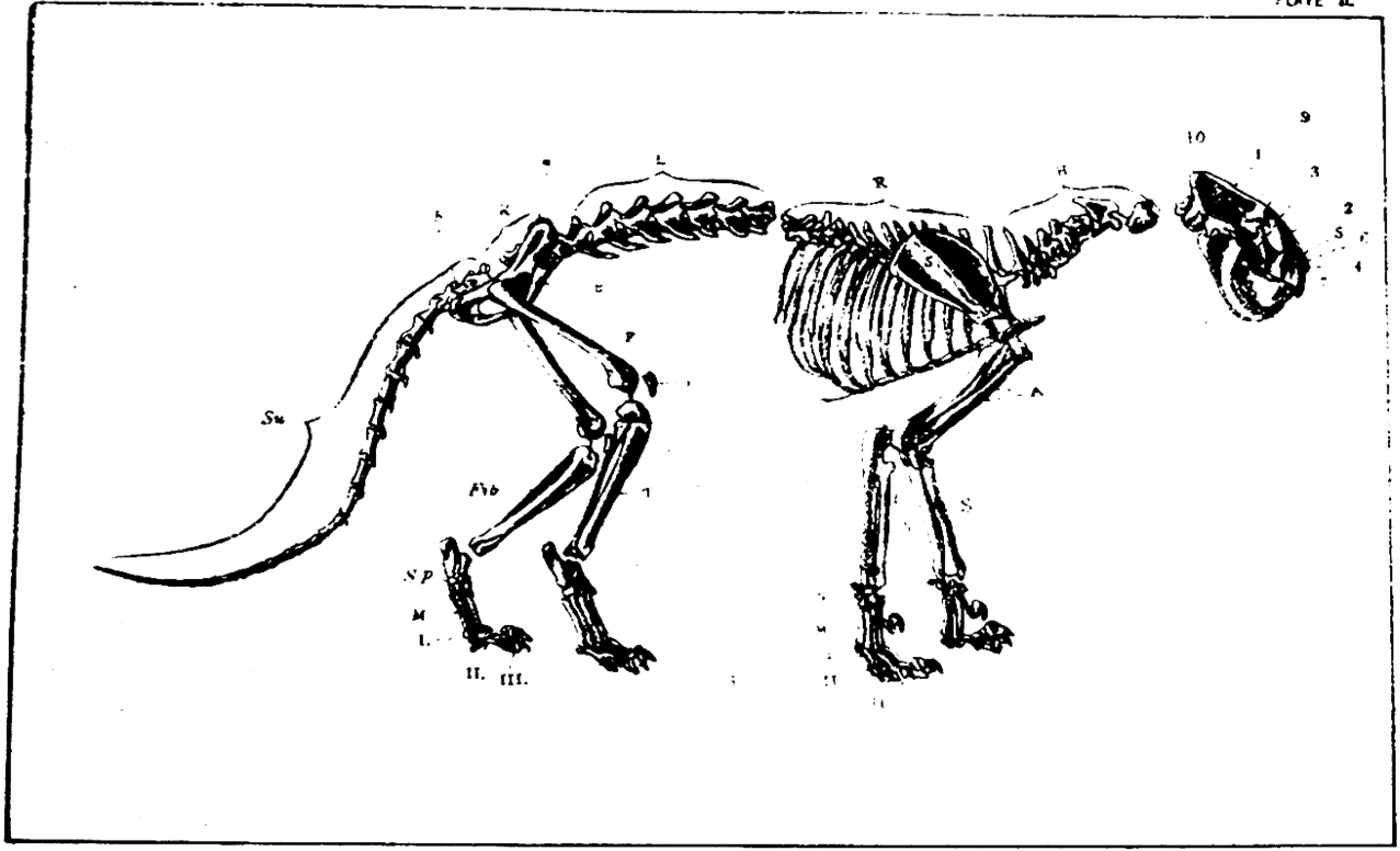
The system of hard tissues when present in an animal is called the SKELETON. The less hard of these are the CARTILAGES, composed of a dense firm substance known as "gristle." The harder are the BONES which are masses of tissue hardened by being impregnated with phosphate and carbonate of lime. Such an internal skeleton is present in man, the leopard (*see* figs. 2, 3), etc. In other cases it may be external as, *e.g.*, the lobster (fig. 30), snail (23), etc.

The axis of the vertebral skeleton is formed by the VERTEBRAL COLUMN (spine) which is composed of flat bones, the VERTEBRÆ. A vertebra usually consists of (1) the body, which occupies the front; (2) the neural Arch, which possesses several projections or processes (neural spine, transverse processes, articular processes) and encloses the vertebral canal (fig. 1, Vc). Mammals, with a few exceptions, have seven neck or CERVICAL vertebræ (fig. 2, 1); while the number of the remaining vertebræ varies according to the genus. The

cervical vertebræ, which support the head, are followed by the dorsal or THORACIC VERTEBRÆ (12 in man, 13 in the leopard, fig. 2(2), 3, R) and these by the strong loin or LUMBAR VERTEBRÆ (5 in man, 7 in the leopard, fig. 2(3), 3, L). The latter are, in their turn, followed by the SACRAL vertebræ, which serve to support the hip—or pelvic—girdle and of which there are usually two, and these again by a varying number of tail or CAUDAL vertebræ. The Cervical, Dorsal and lumbar vertebræ are more or less movable on one another. In man there are 5 sacral vertebræ, united firmly to form a single bone, the Sacrum, and only 4 or 5 caudal, which are all poorly developed and are often fused together (5) and may even be fused with the sacrum, but in many animals there are a large number movably united to make up a tail. This is shown in the tail of the leopard (fig. 3, Su).

The ribs which in mammals bound the chest are jointed to the thoracic vertebræ. Man has 12 pairs of ribs, the leopard 13; each rib consists of a bony part behind and a gristly part in front. The so-called true ribs (the upper pairs) (fig. 2, 14) are movably united with the breast-bone or sternum (16), but this is not the case with the false ribs (fig. 2(15), 3, C).

In the head we distinguish the brain-case or *cranium* and the skeleton of the FACE. The first contains the cranial cavity in which the brain is enclosed. We distinguish—2 frontal bones (fused together in man (6); 2 parietal bones (7); 2 temporal bones (8); an occipital bone (9) composed of several pieces fused together, perforated by the foramen magnum (where brain and spinal chord unite), and bearing two elevations or condyles (so as to join on to the backbone); and the sphenoid and ethmoid bones which make up the base of the cranium. The facial skeleton consists of the framework of the jaws and palate, and together with some of the cranial bones, bounds the cavities in which the eyes are contained (orbits) and the nasal cavities. It consists of the maxillary bones (12), the premaxillary bones (fig. 3, 7), (in man the premaxilla and maxilla of each side early become united to form a single bone), the nasal bones, the lachrymal bones, the ploughshare bone (vomer), the turbinated bones, the cheek bones (or malars) (11), the palate bones, and the lower jaw (13). The last originally consists of two symmetrical halves (fig. 3, 1-10).



3. Skeleton of a Leopard. I. Skull: 1, parietal bone; 2, frontal bone; 3, malar or cheek bone; 4, maxillary bone; 5, lachrymal bone. 6, nasal bone; 7, premaxillary bone; 8. lower jaw; 9, orbit; 10, occipital bone. II. *Neck* and *Trunk*: H, 7 cervical vertebræ; R, 13 thoracic vertebræ; L, 7 lumbar vertebræ; K, sacrum; Su, caudal vertebræ; C, 13 pairs of ribs; D, sternum. III. Fore-limbs: Sc, scapula; A, humerus; S, radius; E, ulna; U, carpus; M, metacarpus; I., II., III. Phalanges. IV. Hind limbs: B, hip-girdle, *a*, ilium; *b*, ischium; F, femur; P, patella; T, tibia; Sp, tarsus; M, metatarsus; I., II., III. Phalanges.

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The upper and lower limbs are built on the same type, and therefore consist of corresponding parts (*cf.* figs. 2 and 3). The more similar the functions of the two pairs, the closer their resemblance. In the leopard or dog they are much more alike than in man; in the bird, on the contrary, the similarity is much less (*cf.* fig. 29). The limbs are attached to the body by means of bony girdles known as the shoulder-girdle and the hip-girdle. Below the parts of the arm and legs of a man are placed together—

Arm.	*Leg.*
I. Shoulder-girdle, consisting of:	I. Hip-girdle, consisting of:
Shoulder-blade (Scapula) (fig. 2,17).	Hip-bone (Ilium) (24).
Collar-bone (Clavicle).	Pubis.
Coracoid process (of Scapula).	Rump-bone (Ischium).
II. Upper-arm:	II. Thigh:
Upper-arm-bone (Humerus) (18).	Thigh-bone (Femur) (25).
III. Forearm:	III. Leg:
Radius (19).	Shin-bone (Tibia) (26).
Ulna (20).	Clasp-bone (Fibula) (27).
IV. Hand:	IV. Foot:
Two rows of wrist-bones (Carpal bones) (21).	Two rows of ankle-bones (Tarsal-bones) (28).
Metacarpal bones (22).	Metatarsal bones (29).
Finger-bones (Phalanges) (23).	Toe-bones (Phalanges) (30).

The difference between arm and leg are explained by their different uses. The bones of the leg, used to support the human body, are firmer and thicker, but less movable than those of the arm, which is employed in grasping. Consequently the union between the hip-girdle and the trunk-skeleton is firmer than that of the shoulder-girdle. The radius can rotate upon the ulna, so as to completely turn the hand over; a similar movement of the foot would not be of use, and cannot be effected. The leg has a knee-pan (patella) (fig. 2 (31), 3, P) with which there is no bone in the arm to correspond. In the foot the toes are short, and the remaining parts long. In the hands the digits are relatively long, and since the tip of the thumb in man, monkeys and a few other animals can be made to touch the tips of the fingers, are admirably adapted for grasping. The number of fingers or toes is at most 5, but may be less. The horse has a single digit to each limb, the ox two well-developed and

two remaining as rudiments; the pig two large and two small, while the dog has four toes on the hind, and five on the fore foot; the leopard 5 on both. Man walks on the sole of his feet. Some other animals (dog, cat) on the toes; others, again (horse, ox, pig) on the tips of the toes, the whole of the tip being sheathed in a horny hoof. In many animals the thigh and upper arm are drawn up close to the body, so that the limbs appear quite different from those of man (*cf.* figs. 2, 3)

5. *Digestive System.*

We have already seen that animals "grow" and that this growth is dependent on their obtaining food and air, the former consisting of complex organic bodies which they reduce to much simpler ones, whilst from the latter they absorb the oxygen giving out carbonic acid gas. These changes, which the food undergoes preparatory to its absoption into the blood, are carried out by the Digestive System. The organs in connection with this system are the *Mouth* and *Teeth* for receiving and chewing the food. The *Gullet* for passing the food into the *Stomach* where it is digested. In addition we have the *Small Intestine* where digestion is completed and the food partly absorbed; the *Large Intestine* where absorption is completed and the *Anus* out of which the undigested residue is cast (fig. 5). In most animals we find that the digestive tract has these two openings, the mouth and anus. The mouth in vertebrates is usually furnished with *teeth* whose chief function is to reduce the food to a condition in which it can be digested. In some animals, however, such as the snakes, the teeth are only used to hold the prey and not for mastication; and in others, such as the turtles and birds the jaws are not furnished with any teeth at all. The food is also usually subjected in the mouth to the action of a special fluid—the saliva—which acts chemically as well as mechanically on the food, and which is secreted by special glands, known as the "salivary glands." From the mouth the food passes through a muscular tube—the gullet or *œsophagus* (fig. 5, g)—to the proper digestive cavity, or stomach(s). Here it is subjected to a special digestive fluid—the gastric juice, and is converted into a thick, pasty fluid. From the stomach this fluid passes into a long convoluted muscular tube, the

small intestine (sm). Here it is subjected to the action of two other digestive fluids, called the "bile" and "pancreatic juice," as well as to the fluids secreted by the intestine itself. The bile is secreted by a large gland known as the "liver," whilst the pancreatic juice is produced by another, termed the "pancreas," both pouring their secretion into the upper part of the small intestine. By their action a milky fluid results which is fit to be taken up into their blood-vessels.

The small intestine finally opens out into a tube of larger diameter, the large intestine (lm) which opens at its lower end on to the surface of the body by an anal aperture (a). In the large intestine the last remaining portions of the food which can be rendered useful are absorbed into the blood, the indigestible portions being ultimately got rid of as useless.

The last portion of the large intestine is usually less convoluted than the rest and is called the *rectum* (r).

All animals, however, have not such a complicated digestive apparatus. In *Amœba*, which consists of a simple jelly-like mass of protoplasm (*see* fig. 7), the animal feeds by pushing out a finger-shaped prolongation of the protoplasm and enclosing the particle of food, then withdrawing the finger, thus lodging the food particle securely within the substance of the body. There is no digestive tract or tube.

In *Hydra*, on the other hand, we have the simplest form of digestive tract in a sac or canal which communicates with the exterior by a single aperture only (*see* fig. 8). This opening thus serves both as an entrance or mouth and also as an exit for the undigested portions of the food.

6. *Respiratory System.*

The cells of an animal must have oxygen in order to live: it must therefore be continually taken into the body and all the cells of the different organs must be supplied. Further, the waste products resulting from the constant combustion going on in the cells must be got rid of: one of these waste products is carbonic acid gas. The absorption of oxygen and the excretion of carbonic acid gas, are always going on synchronously in the tissues; the oxygen being withdrawn

from the blood and the carbonic acid gas given off to it. In order that the blood may be again purified and oxygenated the reverse process must be gone through: this is carried out by means of the Respiratory System. In air-breathing vertebrates, the organs comprised in this system are the nostrils and mouth, the Lungs, and the windpipe, the latter being the passage along which the air is conveyed to and from the Lungs. The blood, as it circulates through these organs, takes up the oxygen of the air, of which it forms about one-fifth, and gives out the carbonic acid gas, which it has brought from the tissues—the two processes again taking place synchronously. The air in the Lungs is renewed at short intervals: the taking in of pure air, inspiration, alternating with the giving out of impure air, expiration, together constituting Respiration. Other animals, however, make use of the dissolved oxygen, which occurs in all natural waters. In such, the gaseous interchange takes place while the blood is flowing through a number of specialised organs—the gills—over which the water is kept constantly flowing. Now it is known that the waste which leaves the body contains more oxygen than the food which enters the body. Indeed, oxidation, the oxygen being supplied by the blood, is going on all over the body. All parts of the body are thus being continually oxidised, or, in other words, are continually burning, some more rapidly and fiercely than others. And this burning, though it is carried on in a peculiar manner, so as to never give rise to a flame, yet nevertheless produces an amount of heat which is as efficient as a fire to keep the body at a temperature of 37°C. (98°6F.) (in man). Nor is it alone heat that is provided by this oxidisation; the energy which appears in the muscular work done by the body has the same source. Just as the burning of the coal in a steam-engine supplies the motive power which drives the wheels, so the oxidation of the muscles (and thus ultimately of the food) supplies the motive power of those muscular contractions which carry out the movements of the body.

It must be remembered that all animals have not a complicated respiratory system. In many animals, which have no respiratory organs, the digestive tract performs the respiratory function. Air, or water containing air, is always swallowed with the food and the oxygen is absorbed during its passage through the digestive organs.

Many of the lower animals (chiefly aquatic), but a few terrestrial (*e.g.*, earthworms), are destitute of special breathing apparatus, and respiration is effected by endosmosis, which goes on all over the surface of the body, the oxygen being taken in and the carbonic acid gas given off all over the body surface. These animals are always thin-skinned. Most animals have, however, distinct breathing organs, assisted in many cases by the skin. In the water-breathing vertebrata, such as fishes, the respiratory organs are in the form of *gills* or branchiæ which are richly supplied with blood and absorb the oxygen from the water. In the case of a fish water passes into the mouth and over the gills and out at the gill cavity frequently. In the air-breathing vertebrates the breathing organs are in the form of *lungs*. These essentially consist of cellular or spongy organs placed in the cavity of the chest, richly furnished with blood-vessels and receiving constant supplies of fresh air, taken in through the mouth and nostrils, by means of a tube which opens in the throat and is known as the "wind-pipe" or trachea.

A peculiar kind of respiratory organ the system of tracheæ, is present in many Arthropods and will be described in detail under the Insects.

7. *Circulatory System.*

We have already seen how food materials taken in are treated in the digestive apparatus, *i.e.*, are digested. In many of the lower animals, the digested food-stuffs, after traversing the alimentary canal, make their way through the various tissues by a kind of endosmosis. In most, however, the system is more complicated. So long as the nutritious food-stuffs remain in the alimentary canal, even though in a completely suitable form, they cannot nourish the body. And since waste of the substance of the body everywhere takes place, it is absolutely necessary that the food-stuffs should pass after digestion into a system of vessels going to all parts of the body. For this purpose there is a special system of branching vessels which conveys the nutritive material derived from the gut all over the body to be absorbed, ultimately, by the tissues. This arrangement of tubes is termed the *circulatory system.* Food substances enter it from the gut either directly or indirectly, in the latter case reaching it through the

lymphatic (lacteal) system. In connection with this system we have to consider the following essentials: The *Blood* and *Blood-vessels*, *Heart*, *Arteries*, *Capillaries*, and *Veins*.

The blood is the fluid into which the food-stuffs are taken up. It consists usually of a clear colourless liquid; more rarely it is yellow or green. Floating in it are numerous free discs which are called blood corpuscles. They are usually red in colour in the vertebrata and account for the colour of our blood. There are also the white amœboid corpuscles. The blood flows through the body in a system of tubes or *blood-vessels* which branch repeatedly, and at last become merged in the microscopic *capillary* blood-vessel. These capillaries are present in nearly all parts of the body except the epidermis and epidermal structures (hairs, feathers, scales, etc.). They have exceedingly thin walls which present no resistance to the passage of the nutritious substances contained in the blood, so that these can be absorbed by those parts of the body which lie between the individual capillary vessels. The central organ of the circulation is the *heart*, an enlarged part of the vascular system possessing thick muscular walls. By the rhythmical contraction of these walls the blood is driven out of the heart in jets (fig. 6, H) leaving at (*a*) since there is a valve at (*b*) which closes when the heart contracts. The vessel into which the blood leaving the heart enters is called an *artery* (A T). It divides into several branches also known as arteries (AT^1 AT^2) and the smallest arteries pass into the capillaries (C) which again are connected with the smallest *veins* (V^1 V^2) which join longer and larger veins until finally one, V, or a few open into the heart.

This is what is known as the *circulation of the blood*.

Now the fluid containing the dissolved or suspended nutritive matters, which are the result of the process of digestion, traverses the very thin layer of soft and permeable tissue which separates the cavity of the alimentary canal from the cavities of the innumerable capillary vessels which lie in the walls of that canal, and so enters the blood with which those capillaries are filled. Whirled away by the torrent of the circulation, the blood thus charged with nutritive matter, enters the heart. In all the mammals this organ is completely divided by a

median septum, iuto two halves, a right and a left. The blood returning from the intestines, and from the other tissues of the body, is poured into the right side, and is then forced through the Lungs: completely oxygenated, it is now carried to the left side of the heart and is thence propelled into the organs of the body. To these organs it supplies the nutriment with which it is charged; from them it takes their waste products, and finally returns by the veins to the heart, loaded with useless and injurious excretions, which sooner or later take the form of water, carbonic acid and urea. When the blood streams through the lungs it gets rid of poisonous gaseous matter taking up oxygen, and when it traverses the kidneys and sweat glands it parts with the injurious liquid and solid substances.

It must be remembered that many of the lower animals, as we shall see later on, have no circulating system.

8. Excretory System.

We have already seen that the food compounds taken into the body are burnt in order to furnish the vital activity; just in the same way as a steam-engine consumes its fuel in order to enable it to move. In the case of the steam-engine it is necessary to get rid of the ashes of the consumed fuel, and in like manner the body has to get rid of the waste products quite as promptly and essentially as nutriment is supplied. This is done by the ***excretory system***, the organs of which are the ***Kidneys*** and ***Skin*** and ***Lungs***. The waste substances, of which the most important are water, carbonic acid, and urea, are got rid of, the carbonic acid and a good deal of water by the lungs; the urea and salts are excreted by two glands called the ***kidneys*** which at the same time pass away a large quantity of water and a trifling amount of carbonic acid, whilst the skin gives off much water, a little carbonic acid, and a certain quantity of saline matter. The secretion of the kidneys is sometimes got rid of by means of special canals adapted for this purpose alone, and there is sometimes a special bladder, the urinary bladder, which serves as a reservoir for urine. In the lower animals there is no special canal, and the excretions are discharged into the lower part of the alimentary canal and are evacuated along with the undigested particles of food.

9. *Nervous System and Sense Organs.*

The Digestive, Respiratory, Circulatory, Excretory, etc., Systems cannot act independently. They are all under control, and the controlling force is the *Brain* and *Spinal Cord*. All animals have not a brain, and the degree of the development of the nervous system varies according to the complexity of the animal. In Amœba there is no nervous system, whilst in man we get the highest development attained. In nearly all vertebrates the central masses of the nervous system consist of the spinal cord contained in the canal formed by the neural arches of the vertebræ and of an anterior mass of nervous matter which is protected by the skull and is termed the *brain*. The size and development of the brain vary greatly. In the lower forms the brain is little more than a collection of nervous masses or "ganglia." These ganglia consist of groups of "ganglion" cells. The "nerves," which consist of bundles of nerve-fibres usually branching in their course, spring from the spinal cord and Brain and supply the various organs. Nerves are called motor or sensory, consisting of motor or sensory fibres. The brain and chord, receive impressions sent from the different sense organs by the sensory nerves; by the motor nerves they transmit impulses to the muscular elements and thus control their movements.

Sensory organs only appear when a nervous system is present. They may be divided into simple and complex; to the former class the organs of touch, taste, and smell belong since they are of simpler structure than the more complex organs of hearing and sight.

The sense of *touch* contrasts with the other senses in that it is distributed over the whole or the greater part of the surface of the body; the entire skin, especially the epidermis, is therefore a sense organ.

Olfactory organs are acted upon by gaseous matters in a peculiar way; they can be ascribed with perfect certainty to only a small proportion of forms, *viz.*, existing terrestrial animals. They consist in Invertebrata broadly of a tuft or tufts of sensory hairs ending at their base in a nerve fibre which passes to the front of the brain. Amongst insects, which have been proved to possess a very acute

sense of smell, the olfactory organs are situated upon the antennæ. These are provided with delicate sensory hairs.

Gustatory organs are affected only by substances in a state of solution; an insoluble powder is inactive. In the Vertebrate they are represented by the so-called taste-buds of the tongue and the walls of the mouth. The buds are supplied with nerve fibres. In fish, taste-buds may occur on the external surface of the body.

Auditory organs usually occur in vescicles filled with fluid. The auditory organs of insects will be considered later.

Optic organs, or the organs of sight, vary in the form ot development. Those of insects will be considered under the chapters on those arthropods.

10. *Reproductive System.*

Reproduction, the formation of new individuals, occurs in the Animal Kingdom in two quite different ways, sexually and asexually.

All Metazoa exhibit *sexual reproduction* which consists essentially in the development of a single cell, after liberation from the parent, into a new individual. Every cell in the Metazoan body has not this property, but only certain peculiar ones called *ova*. As a rule, the *ovum* (which is the female element) cannot develop by itself into a new individual; it must first be fertilised, *i.e.*, it unites with another cell, usually of a smaller size, and always with special properties, a *spermatazoon*, which is the male element. The organ in which the ova are developed is called the ovary. In some cases, as for instance, in some Insects, Crustacea, etc., the ovum can produce a new individual without the intervention of the male (Parthenogenesis). We shall allude to this in the chapters on Insects.

There are two forms of asexual reproduction, *fission* and *gemmation*. In *fission* a longitudinal or transverse furrow appears on the individual concerned, and gradually deepens, until finally the organism divides into two approximately equal pieces, which grow whilst the process is going on, or after it is complete, until each has attained the size of the parent. Less frequently division occurs without the preceding constriction, the animal breaking suddenly into two pieces. *Gemmation* differs from fission in that only a small part of the body of the original individual develops (by rapid growth) into a new

animal, so that it is possible to distinguish between the parent and bud; in fission the two individuals are exactly alike. Various instances of this asexual reproduction are to be met with amongst low animals, such as Cœlentera, Platyhelminths, etc.

Often in gemmation or fission the new individual does not separate completely from the other, but remains in more or less intimate connection with it. In this case if division is repeated, the result is a colony or stock consisting of a varying number of animals produced by a sexual reproduction from one original individual. Stocks or colonies occur especially in Corals, Hydroids, Tapeworms, Polyzoa, and Tunicates.

EXPLANATION OF TERMS.

Analogy.—When in different animals organs are found fulfilling the same purpose and doing the same work, we have a case of *analogy;* the organs are said to be *analogous*, and the one is said to be the *analogue* of the other.

Ex. The wings of a bird, the wings of an insect are analogous to one another since they serve the same purpose; they are not similar however, in any other way.

Homology.—When, in different animals, we find organs having the same structure, whatever their functions may be, we have a case of *homology*; the two organs are said to be *homologous*, and the one is said to be the *homologue* of the other.

Ex. The arm of a man, fore leg of a dog, wing of a bird are constructed on the same type and are *homologous* of one another though they do not perform the same functions. *See* fig. 29.

Fauna.—The general assemblage of the animals of any region or district is called the *fauna* of that district.

Habitat.—By habitat we understand the natural abode of any animal or plant.

Differentiation.—Under differentiation is understood the production of a diversity of parts by a process of evolution or development, *e.g.*, in animal life the germ evolves the digestive and other organs and members. Or when we have an alteration in structure accompanied by a difference in the functions performed we have a differentiation in structure accompanied by a differentiation in function.

Ex. In one animal movement may be performed by the whole body. In another by a part only. In the latter we have differentiation both in structure and function.

Descent.—Animals living at the present day are said to be derived from animals living at former periods by a process of *descent.*

EXPLANATION OF CLASSIFICATION.

The Animal Kingdom is divided into two great sections known as the *Invertebrate* animals or *Invertebrata* and *Vertebrate* animals or *Vertebrata,* the latter being distinguished from the former by the presence of an internal skeleton. These sections are divided up into phylas or branches.

Phylum.—Phylum or branch comprises a group of animals which are constructed upon a common plan or type.

Class.—A class is a sub-division into which the animals constructed upon a common plan (comprised in a phylum) is broken up.

Order.—Each class is divided into *orders.*

Family.—Each order is divided into *families.*

Genus.—Each family is divided into *genera.*

Species.—Each genus is divided into *species* which is the smallest definite division of the Animal Kingdom which will be considered in this work.* Each species or "kind" of animal consists of such individuals as resemble one another in all the essential characters of their structure and are able to produce other fertile individuals like themselves.

Individual.—The members of a species are termed *individuals.*

Variety.—The members of a species are not always exactly alike. A number of its individuals may have some special peculiarity or peculiarities by which they can be readily separated from the rest. Such individuals are termed *varieties.*

Race.—If the peculiarities of a variety are permanent and are handed down constantly by inheritance we get a *race.*

Ex. The different "races" into which the "species" man, consisting of numbers of "individuals," is divided.

* Sub-species, a sub-division of the species are being largely used by some naturalists.

We will take as an example a dog. Its zoological position expressed in full is as follows:—

Phylum	VERTEBRATA.
Class	MAMMALIA.
Order	CARNIVORA.
Family	CANIDÆ.
Genus	CANIS.
Species	CANIS FAMILIARIS.

All species are thus known by the double Latin name, the first being the name of the genus, the second the name of the species.

EXPLANATION OF THE DISTRIBUTION OF ANIMALS.

Distribution in Space.

The distribution of animals in space or their geographical distribution is concerned with the limits within which each species of animal is at the present day confined. Save man, the dog, horse, sheep, mouse, housefly, etc., no species has an universal distribution, and each species is confined to a certain region within wider or narrower limits. The Giraffe, for example, is not known to exist out of Africa, the Kangaroos belong to Australia, the Armadillos to South America, etc. Further, it is possible to divide the earth's surface into a certain number of "Zoological Regions," each of which is characterised by the recurrence in it of certain associated forms of animal life. We have therefore to consider here, firstly, the geographical range of each species of animal; and, secondly, to determine what general assemblages of animals (fauna) are characteristic of certain large areas or provinces.

The spread of land animals is determined by the presence of natural barriers, such as lofty mountain ranges and seas, which they cannot cross. Owing to their power of flight the distribution of birds is not so limited but both birds and mammals can be given certain fixed provinces.

The distribution of an animal at the present day by no means necessarily coincides with its former extension. It may be more widely or less widely distributed now than formerly.

The ea.th's surface is divided into three primary zoological divisions or zoological realms known, respectively, as the Arctogæa, Notogæa and Neogæa .* The Arctogæan realm comprises 5 regions —the Sonoran, Holarctic, Ethiopian, Malagasy and Oriental. The greater part of India and its dependencies are included in the Oriental. The Higher Himalayas are within Holarctic limits and the fauna of Western India contains too large a proportion of Holarctic, or as they are generally called Palæarctic, types for it to be included in the Oriental or Indo-Malay region.

It must be understood that the regions named are founded on the distribution of Mammalia and are not either necessarily, or, in fact, indentical with those which correspond with the distribution of other classes cf Vertebrata or of any Invertebrates. The class of Birds, taken as a whole, appears to coincide better with the Mammals in distribution than other classes do.†

The Neogæan realm includes the Neotropical region. The Notogœan realm includes the Australian, Novo-Zelandian or Polynesian and Hawaüan regions. Each of these regions is characterised partly by the presence of a particular 'fauna' or assemblage of animals and partly by the absence of certain other characteristic animals.

The areas comprised in the regions and animals characteristic of them are:—

I. ARCTOGŒA.—

1. *Holarctic Region (Palæarctic and Northern Nearctic)*—Including Europe, Africa, north of the Atlas Mountains, Northern Asia and north of North America. Characteristic animals are the Roe deer, Goat, Moles, Badgers and Magpies (Pica) and true Partridges (Perdix.)
2. *Sonoran Region (Southern Nearctic)*—southern portion of North America down to the centre of Mexico. Characteristic animals are the Musk rat, Pouched rats (Geomys), Prongbuck or American Antelope, American

* LYDEKKER.—A Geographical History of Mammals, pages 27, etc.

† BLANDFORD.—The distribution of Vertebrate Animals in India, Ceylon and Burma, Phil. Trans. Royal Soc., London. Volume 194, page 337.

deer (Cariacus) and the Turkey. The Beaver, Reindeer, Sheep and Bears are types common to this and the Palœarctic region.

3. *Ethiopian Region*—Including Africa, south of the Atlas Mountains and Southern Arabia. Animals are African Elephant, Hippopotamus, Giraffe, Hyrax, numerous Antelopes, Baboons and Ostrich. There is a characteristic absence of Bears, Deer, Goats and Sheep.

4. *Malagasy Region*—Includes Madagascar, Mauritius, Sychelles, etc.). Characteristic animals are Lemurs, civets, mungooses, musk, shrew and *Muridæ*.

5. *Indo-Malayan Region (Oriental)*—Including Asia, south of the Himalayas, Burma, Siam, Southern China and the Indian Archipelago (Java, Sumatra, Borneo, etc.). Characteristic animals are the Gibbons, Lungurs, Indian Elephant, Gaur, Sambar, Muntjac, Chevrotain, Paradoxurus, Tupaias, Hornbills, Pea fowl and Jungle fowl.

II. NEOGÆA.—

Neotropical Region—Including the whole of South America, Central America and Southern Mexico together with the Antilles. Characteristic animals are Platyrhine Monkeys, Llamas, Peccaries, Sloths, Ant-eaters, Armadillos, Humming Birds, Toncans, Curassowos, Tinamus and Rheas. There is an absence of insectivorous Mammals, Goats, Antelopes, Oxen, Cranes, etc.

1. *Australian Region*—Including Australia, Tasmania. Characteristic animals are the Duck mole, Indian Pangolin, numerous Marsupials, Birds of Paradise, Cockatoos and Australian Mud Fish.

There is a remarkable absence of most orders of Placental Mammals, of Vultures, Woodpeckers and tailed Amphibians.

III. NOTOGÆA.—

2. *Novo-Zelandian or Polynesian Region.*—New-Zealand and Polynesia. Animals resemble Australian save that there are no Marsupials, Monstremes or reptiles except a few lizards and Hatteria or Sphenadon.

3. Hawaiian Region.—Hawaia and characteristic animals are a bat (*Atalapha*) and Passarine birds.

Leaving the dry land we find that even the Ocean animals are not distributed at random. Some live on that portion of the sea-shore between high and low tides so that they are uncovered by the water twice a day. Next we find animals living just below low-tide mark and to a depth of 15 fathoms. Beyond this are other regions of various depths which can usually be recognised by the animals inhabiting them, and finally we get the distinct "deep sea" inhabitants living in water from 300 fathoms to 3,000 to 4,000 fathoms. There are also distinct genera inhabiting the polar, temperate and torrid zones and some differences occur between the forms found in the different oceans.

DISTRIBUTION IN TIME.

The distribution of animals in time or their geological distribution is a very vast subject. It will be sufficient to mention here that the various kinds of rock composing the earth's surface often contain what are called "fossils" or "petrifactions"; in other words, the remains or traces of animals and plants which lived at the time the rocks were being formed. In rocks which have been formed in the sea, the fossil consists of skeletons of shell-fish, corals, sea urchins, etc.; and in rocks which have been formed in lakes or rivers we have fresh-water shells and skeletons of fresh-water fish; and in ancient soils as well as in fresh water deposits we find the remains of plants, along with air-breathing animals, such as spiders, insects, or beasts. An examination of these has shown that the history of the earth can be traced throughout a series of periods each marked by a distinct fauna.

Further, it must be borne in mind that animals at present living on the earth present a general likeness to those dwelling on the earth in the later periods of its history, though they are not identically the same. Those living in earlier periods, however, are not only "extinct," but they are very unlike those seen at the present day. No fossil, however, has yet been found which cannot be classified in one or other of the existing phyla.

A MANUAL OF

ELEMENTARY FOREST ZOOLOGY

CHAPTER I.

SCHEME OF THE ANIMAL KINGDOM.

All animals, like plants, are made up of cells.

The animal cell usually consists of a substance called protoplasm a finely divided viscid substance of which the most important constituent is albumen. Protoplasm also contains a considerable quantity of water and of various other materials. In the protoplasm is a rounded or oval body, the nucleus, and in this again is a smaller spherical body, the nucleolus. The protoplasm may or may not be surrounded by a thickened layer or "wall." An Infusorian animalcule, a microscopic organism found in dirty water, is a good example of a protozoon with a thickened wall round the protoplasm.

PROTOZOA.

Some animals never get beyond the stage of this single cell and are then called *protozoa* (Gr. *protos*, first; and *zoon*, an animal). These protozoa may be defined as unicellular animals which may be colonial (*i.e.*, may consist of a number of cells joined together), but then the members of the colony are all alike. This is the lowest division of the Animal Kingdom. The protozoa have no organs at

all. No definite body cavity and no nervous system, and definite digestive organs are absent. They are mostly microscopic animals which are widely distributed in great multitudes in the seas, fresh waters, and damp places on land. The *Amœba* is a typical example of the group. It is a microscopic organism which is frequently found in fresh water. Its shape is irregular and indefinite. It consists of the one cell (fig. 7) having the above described structure but with no wall surrounding the protoplasm. It has the power of movement, small processes, called *pseudopodia*, being thrust out from the surface by the straining of the general substance of the animal towards certain points, and the pseudopodia then disappear, and new ones are formed; but apart from this the protoplasm is in constant motion as is shown by the way the granules move about, and this mobility of the protoplasm enables the Amœba to glide about through the water. The food is caught by means of the pseudopodia and the undigested residue is got rid of by the protoplasm flowing away from it.

METAZOA.

Further advance in size and complexity of animals depends on multiplication and union of the cells and multicellular animals, *i.e.*, those in which the individual is made up of more than one cell are called METAZOA. The union of cells is not possible to any extent if all the cells remain exactly alike. The metazoon begins life as an ovum, a small corpuscle of living protoplasm provided with a nucleus, and at this stage agrees in all essentials with the Amœba. It does not remain, however, in this state; the ovum divides into a number of segments, each with its own nucleus, but instead of separating from one another, they remain in connection; such segments are called cells and the body of the metazoon attains its definite form by repeated division and differentiation of the cells. The perfect metazoon then is an intimate association of cells like an Amœba, but showing greater or smaller modifications.

The expression "division of physiological labour" is used to express the fact that a sort of rough correspondence exists between lowly and highly organized animals and plants, just as it does between lowly and highly organized human beings. In primitive communities there is little or no division of labour. Every man is his own butcher, baker,

doctor, etc., and is more or less indepenuent of the rest. Whereas in complex civilized communities society is differentiated into politicians, butchers, bakers, soldiers, etc., each class being dependent on the others. The same thing occurs in the more complex animals, cells being differently modified for different work.

CŒLENTERATA.

We have seen that union of cells is only possible if the cells do not remain exactly alike. Some cells undertake digestive functions, others respiratory, etc., etc., and hence by adaptation to special functions the cells tend to become unlike one another, and we have differentiation and organization under control. The simplest stage of differentiation occurs when cells become arranged in two layers, an outer, which is a sensory or protective layer, and an inner, which is the digestive one. This latter forms the wall of a simple cavity open at one end; the cavity is the digestive cavity and the opening is at once mouth and anus. An animal known as a *Hydra* has this structure. Fig. 8 shows a species of Hydra known as *Hydra fusca*, and a longitudinal section of the same. Such animals are known as CŒLENTERATA. With very few exceptions the Cœlenterata are marine animals. Examples of the group are the Hydras, Coral Polyp, and Jelly-fish. They are not of importance for our purpose, but the student should notice that the complicated system of organs described in the Introduction to this work are not found in the Cœlenterata.

CŒLOMATA.

All the higher animals have, in addition to a digestive cavity, a second cavity known as the body cavity or CŒLUM, and are known as CŒLOMATA. In these animals the digestive cavity, now called the *alimentary canal*, is quite separate from the body cavity; it passes through the latter without opening into it just as the chimney of a lamp passes through the globe (*cf.* fig. 9). Except when they are parasites, all the Cœlomata have some of the system of organs described in the Introduction.

The Division Cœlomata is divided, according to the complexity of their structure, into seven principal PHYLA or BRANCHES.

PHYLUM I.—PLATYHELMINTHES or Flat Worms.

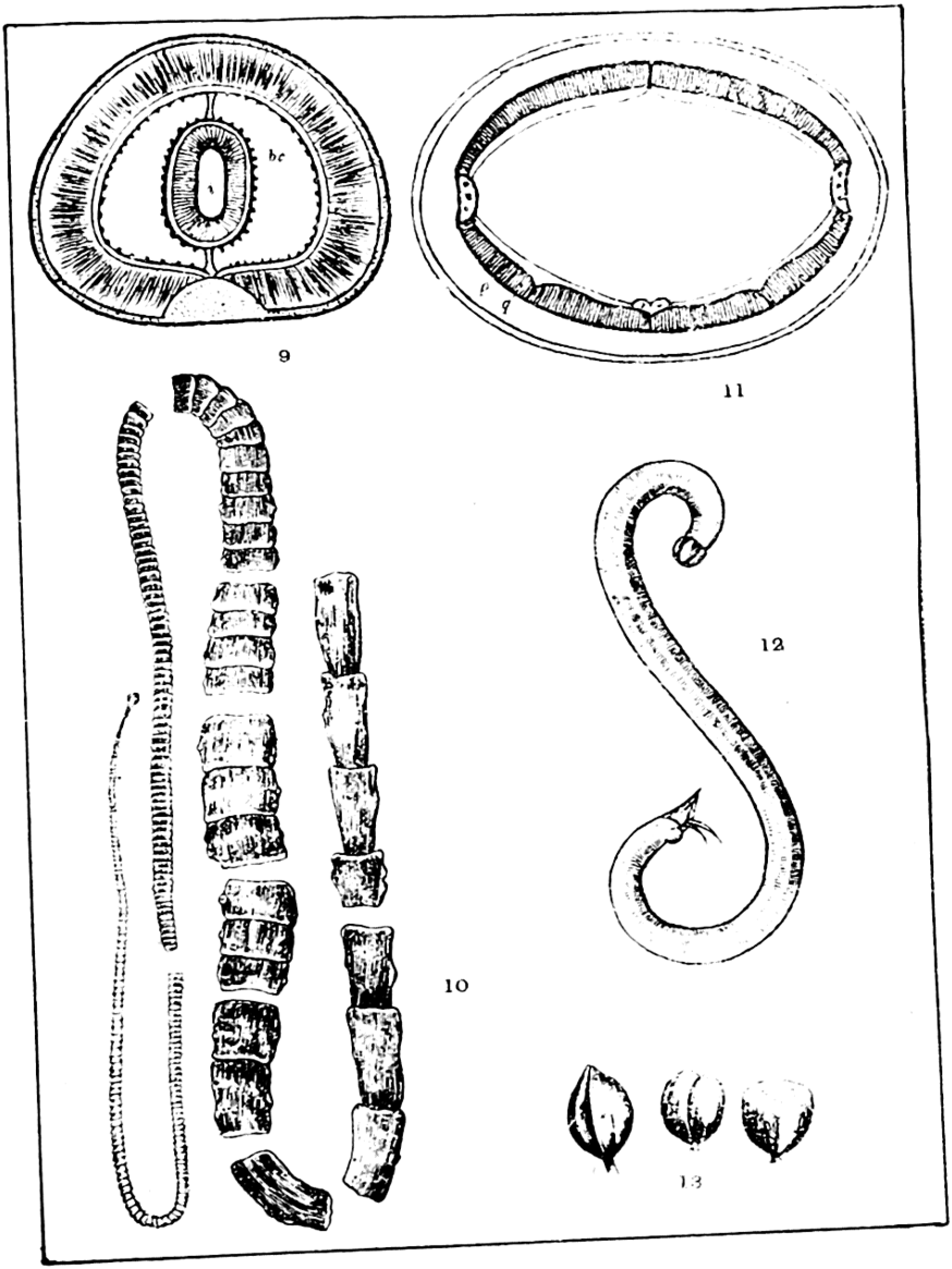
The Flat Worms are bilaterally-symmetrical, unsegmented animals with a flat, generally leaf-like body and usually no body cavity, the space between the internal organs and the muscular body wall being filled up with connective tissue. Sometimes eyes are present, situated anteriorly. Both male and female reproductive organs are present in the same individual. These animals live in fresh or salt water or even in damp places on land, or are parasitic in other animals, such as fish, mammals, etc. The tapeworms (Class *Cestoda*) parasitic in birds and mammals, etc., are examples of this phylum.

CLASS.—CESTODA.

The external parts of an ordinary tapeworm (*see* fig. 10) consist of a very small "head" continued behind into a small "neck" followed by a very large number of joints of which the first are very small and short, whilst those which follow get larger and larger the further they are from the head. Each joint may be looked upon as an individual; it is furnished with male and female organs, and becomes sexually mature without reference to the other joints. When mature, it breaks off, creeps about, perhaps for a considerable time, and then finally ruptures, liberating numerous eggs. Thousands or even tens of thousands of joints may be produced by a single joint. The tapeworm is a species of animal which exists in two forms. The larvæ developing from the liberated eggs become in another host *bladder-worms* or *measles*.

Life-history of the Tapeworm of the dog.

An example is the Tapeworm of the dog, *Tænia casenurus*. This tapeworm, which may live in the intestines of other animals besides the dog, has a circlet of hooks on the head, by which the animal holds fast to the intestinal wall, is from 14 to 16 inches long, and consists of about 200 joints. It generally lives in the intestines of the sheep-dog in correspondence with which is the fact that the bladder-worm, which is the second form, lives in the brain of young sheep. If a sheep-dog harbours the tapeworm in its stomach, a sheep may very easily take up a passed-out joint with the grass it feeds upon. The joint is then digested in the sheep's intestine and the larva escapes from the egg. It bores through the wall of the sheep's intestine, gets into the circulation, and is carried by the blood stream to various parts of the body; it can only develop further, however, in the brain (or spinal cord). After the minute larvæ have reached the cavity of the cranium they move about on the outer surface of the brain and dig out channels



9. Transverse section of a worm to show the body cavity. *bc*, body cavity; *i*, intestine.

10. A Tape-worm (*Tænia*): head and a number of joints (nat. size).

11. Diagrammatic section through the body of a Thread-worm, internal organs being omitted. *p*, cuticle and skin; *q*, muscle layer; *a*, lateral lines; *b*, dorsal and ventral lines.

12. A parasitic Round-worm.

13. Ear Cockles of wheat: eel-worm larvæ shown on cut surface. (Figs. 11 and 13 after Ritz Bos.)

[to face page 5.

until they find a suitable place for further growth. The larva now becomes a bladder-worm which gradually grows until it attains a size varying from a nut to a hen s egg. It develops numerous tapeworm heads, as many as three to four hundred. These become tapeworms if the sheep is finally killed by the parasites, and its head devoured by a dog or fox. The disease in the sheep produced by the bladder-worm (*Cœnurus cerebralis*) is called 'sturdy or staggers.'

PHYLUM II.—NEMATHELMINTHES or Round Worms.

The Round Worms are bilaterally-symmetrical, unsegmented animals, with a cylindrical body; the body wall is tough, and hooklets or spines may be present on it, but deeply embedded bristles are always absent. The gut may be absent, but this is exceptional.

There are no special organs for circulation and respiration. The sexes are distinct in the large majority. Only the class *Nematoda* needs consideration here.

CLASS.—NEMATODA (Thread Worms).

Elongated, thread-shaped or spindle-shaped, unsegmented. A gut terminating in a ventral anus is present. The outer investment of the skin is smooth, often weakly ringed or striated. The muscle layer under-neath the true skin is interrupted here and there, when the skin itself stretches further inwards (fig. 11). The mouth is usually surrounded by lip-like folds, but more or less distinct jaws may also be present. The anus either lies at the apex of the tapering posterior end of the body or further forward on the ventral surface (fig. 12). The nematodes are mostly parasitic, though some small forms are free-living in fresh water, damp earth, or in the sea, and others in decayed substances

The *Nematodes in the Gut* consist of many species belonging to several families. They exist more in young animals than in old and cause the following symtoms: (1) Appetite variable; (2) nutrition in general affected, even if sufficient food is taken; constipation or diarrhœa; belly much drawn in, or else usually swollen out; the animal itself is thin and has (except horse) a tendency to vomit; (3) an itching all over the body, especially at the nostrils and anus; the animal rubs and bites the sides of its body; (4) tongue covered with a thick, soft, yellowish coating; a sweet smell from the mouth; (5) the skin is tense, lacking its usual elasticity; (6) the animal suffers from spasmodic colic; and (7) disturbances of the nervous system (whining or crying, unrestrained or suppressed fits).

or living plants. Many of the parasitic forms live in different hosts at different periods, or are free-living at one period, parasitic at another. Some live in this way in damp earth at one season and bore into insects at another.

Family.—*Anguillulidæ* (Eelworms).

The family *Anguillulidæ*, which may be taken as a representative one of the class, is one of some importance since it contains several most destructive crop pests.

Eelworms are extremely small, and thin skinned; they lay only a few relatively large eggs, which develop very quickly. They live in humus or as plant parasites, leading to characteristic diseases. All these parasitic forms may be recognised by the presence of a "mouth spine." This structure, found in the mouth cavity, is very sharp and pointed in front, and can be worked forwards and backwards so as to penetrate the cell walls of plants. This mouth spine is found not only in the species which infest plant tissues (species of *Tylenchus*, *Aphelenchus*, *Heterodera*), but also in those forms living free in the earth which bore into the exterior of plant roots. In all cases an eelworm devoid of a spine is not a plant parasite. As typical of this family, we will consider here the wheat eelworm, *Tylenchus scandens*—causing a disease well known in England, Germany, France, and Italy, a quarter of the wheat crop being sometimes destroyed by it.

Life-history of the wheat eelworm, *Tylenchus scandens*.

The length of the male is about one-twelfth of an inch, of the female one-tenth to one-fifth (according to the size of the galls in which the eelworms develop). The wheat eelworm is the cause of "ear-cockles" of wheat. In several parts of the ear short, thick, dark-brown galls (*see* fig. 13) are found instead of wheat grains. Inside the thick brown shell there is a yellowish-white mass containing hundreds and even thousands of eelworm larvæ ($\frac{1}{51}$ to [illegible] of an inch long). These are quite dry and rigid, but gradually revive on moistening even if the galls have remained 20 years in the dried-up condition. When the wheat is ripe the dark-walled galls are gathered in with the crop, and in many cases are sown again with the sound grains. Under the influence of moisture the brown shell soon decays, and the eelworm larvæ leave the gall, travel to a neighbouring wheat seedling, where they live between the leaf sheath and haulm; they also penetrate into the terminal bud. The haulms of a wheat plant infested by many eelworms remain relatively short; the leaves are

often sharply bent and have wavy margins. The eelworms quickly tra from all parts of the plant into the ears, and get into the rudiments of the flowers causing them to swell up like bladders, and their walls to become first dark-green, and then dark-brown. Sixteen to twenty eelworms are present in the lowest flowers of the ear, ten to twelve in those higher up, and four to six in the topmost and therefore smallest. Soon after entering the flowers the eelworms become sexually mature and lay eggs (600 to 1,600) from which are developed the larvæ which inhabit later on the cockle-seed like gall.

PHYLUM III.—ANNELIDA or Earthworms, Seaworms, Leeches.

Segmented worms with rounded (earthworm) or flattened (leech) bodies and possessing both mouth and anus. The segments are relatively similar. Limbs when present are unjointed. They have a body cavity and usually a circulatory system. The nervous system consists of a pair of nerve cords situated along the ventral surface below the alimentary canal, which are connected with a pair of ganglia lying above the pharynx (fig. 14). Eyes feeble. There are a pair of tubular excretory organs in most segments (segmental organs). The elongate body consists of a number of *somites* or segments which are separated externally by constrictions. The segments resemble each other to a certain extent, both in their internal and external structure, although they are never all identical, the first or several anterior segments and the last always differing from the rest. The mouth is close to the front end. The alimentary canal, consisting of several regions, usually traverses the body without convolutions. The anus is at the hind end (fig. 14). The sensory organs are often represented by tactile threads (tentacles, etc.). The circulatory fluid is sometimes yellow, sometimes green. Some annelids are of separate sexes, others hermaphrodite.

Three classes of annelids will be shortly noticed here.

CLASS I.—CHÆTOPODA.

Most Chætopods are marine and for the most part creep about on or burrow into the soft bottom of the ocean (some species bore into

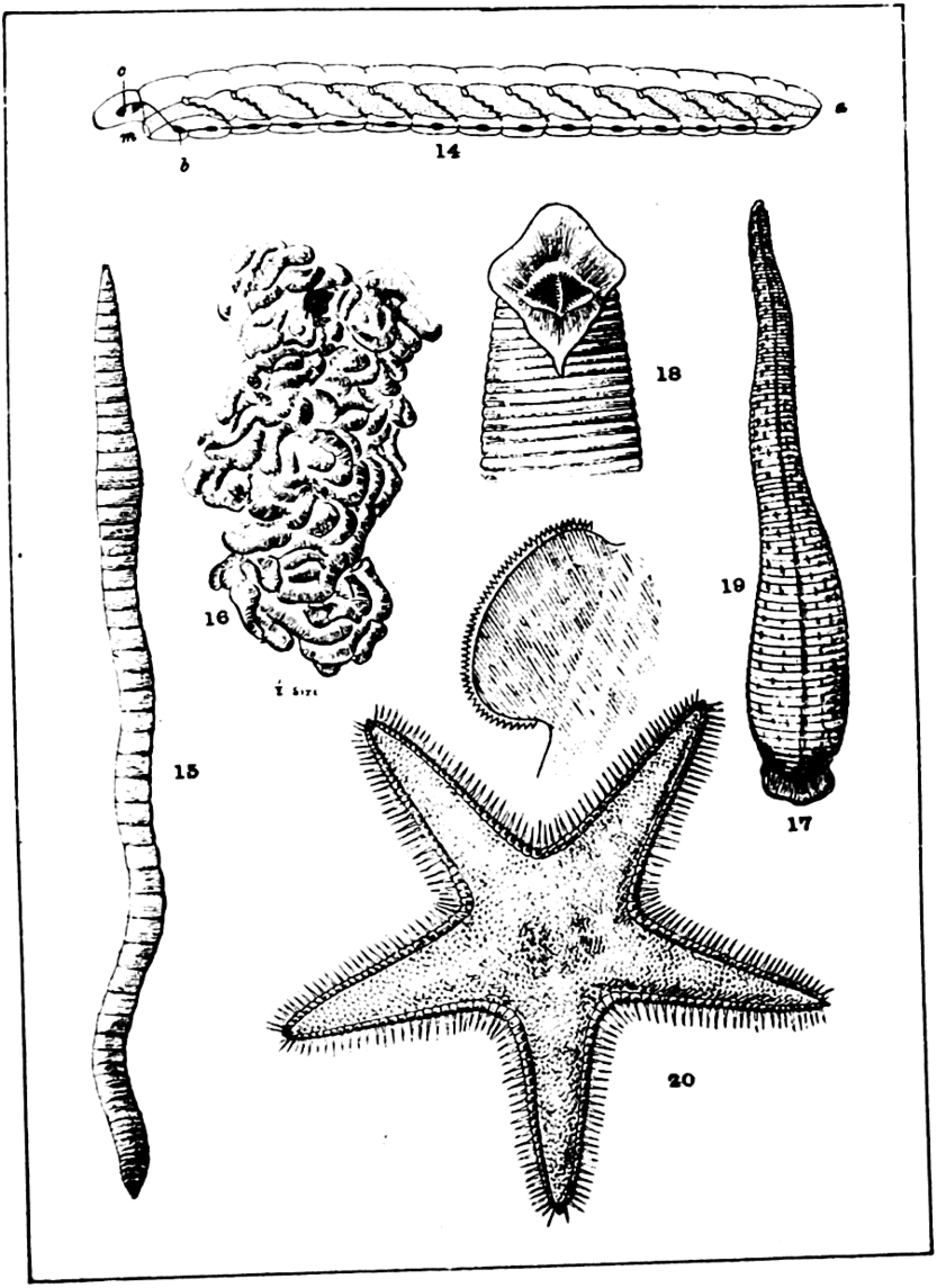
* The stem eelworm (*Tylenchus devastrix*) infesting rye, oats, stored onions, buck wheat, potatoes, clover, etc., the Beet-eelworms (*Heterodera schachtii*) and the Root-eelworms (*Heterodera radicicola*) are other bad European crop pests, and as our knowledge increases, it will doubtless be found that India has several noxious species

rockstone or clay, but it is not understood how they do it); others live in like manner in fresh water or in damp earth. A considerable number form tubes consisting of foreign particles, mud, clay, sand, etc., cemented together; this tube increases in size as the animal grows.

An earthworm (*Lumbricus*) is a typical example of this class. It has an elongate cylindrical body, tapering in front (fig. 15). Eyes are absent. On the ventral side of the second segment is found the opening of the mouth. Just in front of the middle is the *clitellum*, a thickened region of the skin covering several segments and containing a large number of glands whose excretion is connected with copulatory action. The earthworm is hermaphrodite; when two individuals pair they mutually fertilize one another.

Life-history of the Earthworm.

The eggs, of which a large number are generally laid, are surrounded by a substance which is secreted by the glands of the clitellum, and surrounds them as a capsule as they are being laid. Earthworms of different species live in cultivated soil, in which they burrow and upon which they feed. They are chiefly found in damp humus, or, at any rate, not in very poor sandy soil or clay. From time to time they carry their burrows up to the surface in order to get rid of the undigested remains ("worm castings") (see fig. 16) of the humus and vegetable matter which they have taken into the body. The burrows run down into the soil at an angle to as much as eight feet below the surface, scarcely ever being taken down vertically; they end in an enlargement, where the worm remains coiled up during the winter after closing the mouth of the burrow with a plug of leaves, twigs, etc. In severe cold, as in very great heat, the worm leaves the surface soil and goes into the substrata; here the holes are long, usually perpendicular, and lined with an excreted substance. Earthworms consume dead vegetable matter, also assisting its decomposition by drawing it into their holes and pouring over it a salivary liquid. The excreta are deposited for the most part at the surface, whither the animal usually repairs only at night. Earthworms may effect at times considerable damage by destroying seedlings, particularly in damp places. The benefit they do, however, is very great. They are very abundant in the soil and their numerous burrows enable air to penetrate into the soil much easier than it could otherwise do, and this is of the greatest importance to plant life. There is another reason. Darwin has shown that a weight of ten tons of earth per acre passes through the bodies of earthworms, and is brought to the surface by them, so that in a few years the entire humus containing surface layer of earth has passed through their bodies. They therefore prepare the soil in an excellent manner for the growth of plants, by continuallv exposing it to the air. By these habits,



14. Annelid seen from the side; diagram of the alimentary canal of the nervous system, and the segmental organs. *m*, mouth; *a*, anus; *c*, cerebral ganglion; *b*, sub-œsophagal ganglion; *s*, segmental organ. (After Boas).

15. An Earth-worm.

16. Earth-worm castings.

17. A common Leech.

18. Head of a Leech showing the mouth and three jaws.

19. One of the jaws magnified showing the teeth.

20. A Star-fish Echinoderm.

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especially by devouring soil and replacing it on the surface in the form of excreta, the earthworm thoroughly mixes together the particles of the soil and thus does more than any other animal to promote the natural elaboration of the soil, and attains thereby a paramount importance in the economy of nature. When a locality is deserted by earthworms on account of, *e.g.*, an inadequate supply of moisture, the surface soil changes and assumes a dry turfy character; should this occur in a forest, natural planting, by self-sowing, ceases, and unless man interfere, the wood gradually becomes a moor.

CLASS II.—DISCOPHORA (Leeches).

The body is usually flattened, having sharp lateral edges, rarely cylindrical. The segments are externally divided each into several small *annuli* by transverse furrows, so that the number of the segments appears many times greater than it is in reality (*cf.* fig. 17). The posterior end of the body is modified into a sucker. Around the mouth there is also an adhesive disc, which in some is cup-shaped like the hinder one (fig. 17), whilst in others it consists of a long, jointed upper lip and a shorter under lip. The digestive tract consists of three sections: the pharynx, the crop, and the rectum. In one group, the *Gnathobdellidæ*, the pharynx is muscular, and furnished in front with jaws, three prominent, longitudinal, chitinous ridges, with teeth on their sharp edges, which work like little saws to cut holes in the skin of the prey, (*cf.* figs. 18, 19), so that the fluids may be pumped out of its body by the pharynx. In the other division, the *Rhynchobdellidæ*, on the other hand, a thin muscular tube, the probcscis, is attached to the end of the thin walled pharynx. It may be stretched out from the mouth and pointed, so as to bore through the integument of the prey. The crop is a straight, wide tube, which is almost always provided with a number of paired diverticula; the capacity of the crop and its diverticula allows for the taking in of a large amount of food. The intestine is narrow and opens dorsally above the sucker.

The leeches are always hermaphrodite. The eggs are laid in chitinous capsules (cocoons), usually several together with a certain amount of albumen. The young ones leave the cocoons in the form of the adult. The leeches are well represented in fresh water, though a considerable number are marine. Some are terrestrial, especially so in the tropics, and others frequently go ashore. They are predatory or

are temporary parasites, sucking the blood of larger animals; some are stationary parasites. They creep about in the well-known manner by means of their suckers; but are also able to swim by serpentine movements of the body.

Leeches are often a source of considerable annoyance in many Indian forests during the rainy months, and in moist damp places at all seasons except the coldest months of the year, and this is more especially the case in the hotter parts of the country. Areas in the eastern outer Himalayas on which more or less permanent grazing takes place appear to invariably swarm with leeches. Damp hot tropical forests like those to be found in the southernmost portion of Chittagong, Arakan, Lower Burma, Malabar, etc., invariably abound with leeches.

PHYLUM IV.—ARTHROPODA.

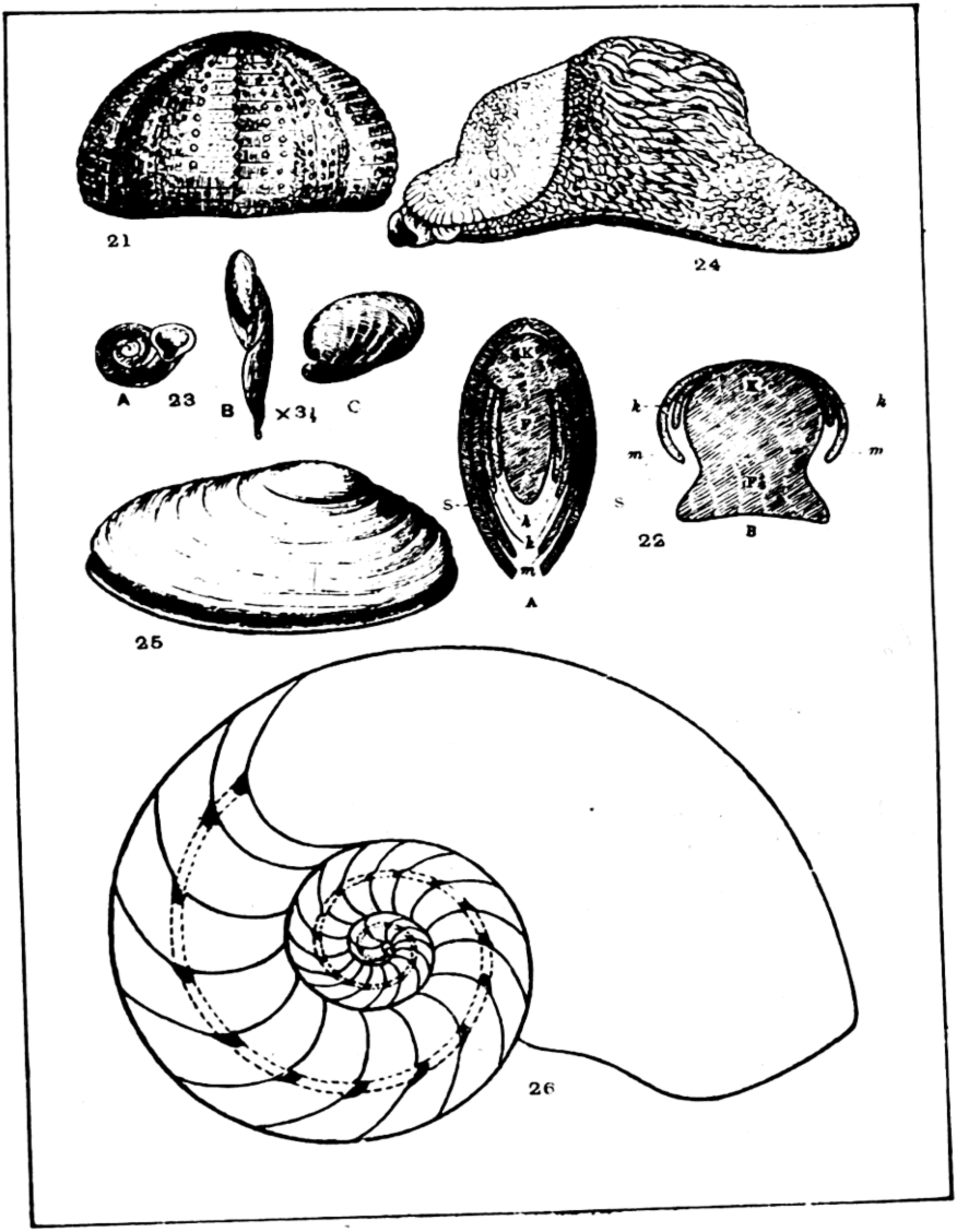
The Arthropoda are bilaterally-symmetrical, segmented animals, the segments being modified in various ways. The limbs are jointed. The dermal skeleton is formed from a well-developed cuticle (chitin). A body cavity is present. The heart is on the dorsal side and the nervous system as in Annelida. Highly specialized sight organs (compound eyes) are present. The segmental organs are always much reduced in number, or entirely wanting.

Examples of this group are the Prawn, Crab, Spider and Scorpion Insect, Millipede and Centipede.

From the forester's point of view this is the most important, as it is by far the largest, of all the phyla, and we shall return to it later and consider it in detail.

PHYLUM V.—ECHINODERMATA.

The Echinoderms are radially symmetrical animals, that is, a number of similar parts which together make up the body are arranged around an axis (fig. 20). These animals are usually 5-rayed. The mouth is situated at the lower end of the axis of the body. There is a body cavity, a circulatory system, and a special water circulatory system. The dermal skeleton either consists of numerous minute calcareous deposits or of hard plates. In some the radial symmetry is indistinct



21. A Sea Urchin.

22. Diagrams to explain the form of the body of a Mollusc. A, a bivalve Mollusc; B, a Snail (cross sections). In both: K, body; F, foot; *s*, shell; *m*, mantle; *k*, *k*, gills. (After Ritz Bos.)

23. Characteristic Indian Mollusca. A, *Hypselostoma tubiferum*; B, *Camptoceras terebra*; C, *Camptonyx Theobaldi*.

24. A Slug with body drawn up.

25. A fresh-water bivalve Mussel.

26. The Nautilus, the shell sawn through.

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and there is a more or less distinct bilateral symmetry. Echinoderms move by means of rows of tubular feet (*see* fig. 20). The tube feet are soft, delicate, usually cylindrical structures, the fore ends of which are either provided with suckers or rounded; only in the former case do they serve as organs of attachment. The skin is often lightly coloured. Echinoderms are all of separate sexes. Examples of this phylum are the Star-fish and Sea Urchin.

In the Star-fish the flattened body consists of a disc with five or more arms (fig. 20). In the Sea Urchin (fig. 21), on the other hand, the body is sometimes almost spherical, but in most it is spheroidal or heart shaped; arms are completely absent. The greater portion of the body wall is furnished with immovably connected calcareous plates some of which bear movable spines.

(*N.B.*—There are a few sea urchins in which the plates are jointed.)

Echinoderms are entirely marine and are not of importance to the forester.

PHYLUM VI.—MOLLUSCA (Molluscs).

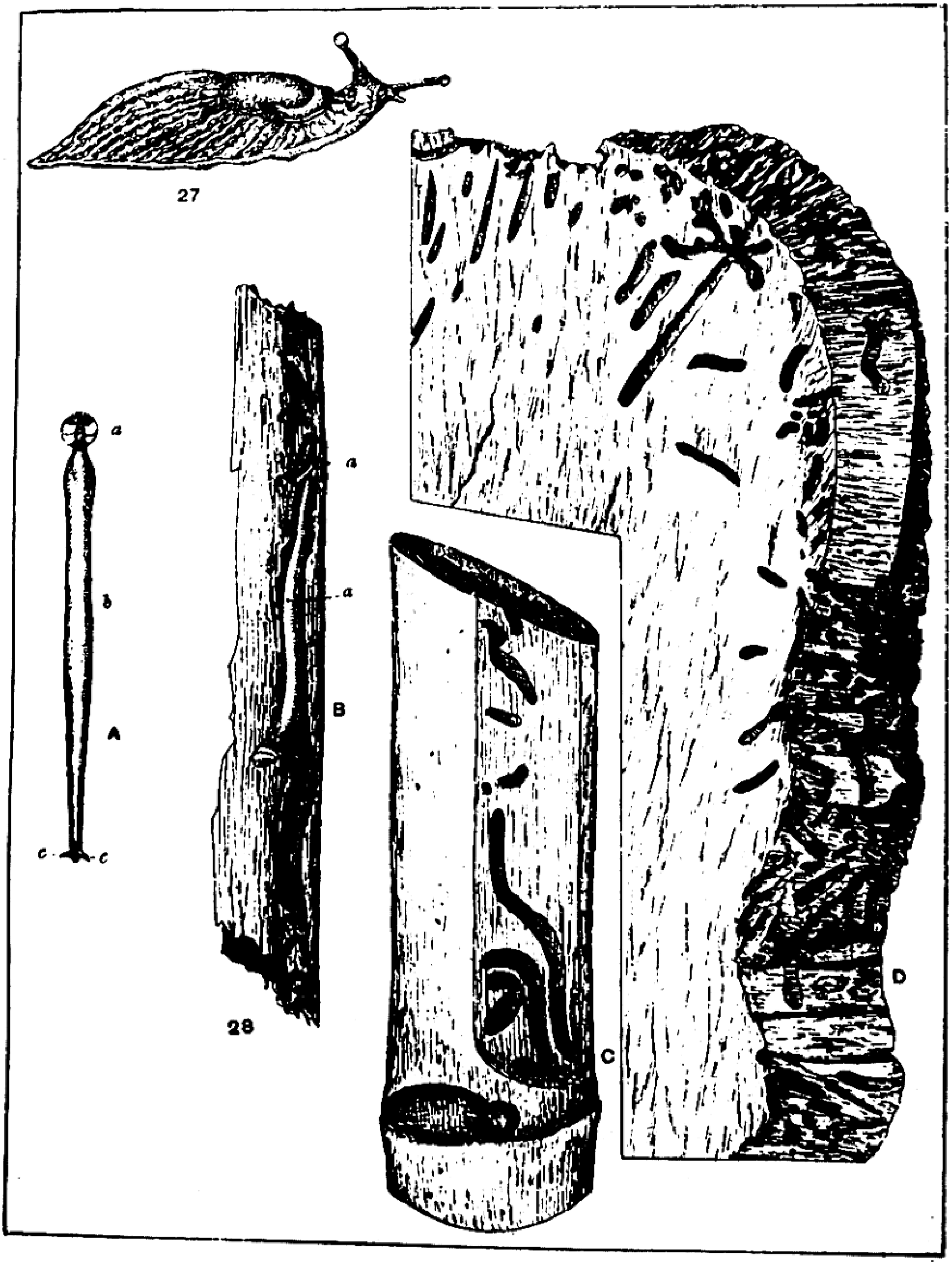
This phylum, to which oysters, snails, slugs, cuttle-fish, etc., belong, includes unsegmented animals with a bilaterally-symmetrical embryo, while the adult may be much modified, especially in snails, which are enclosed in spiral shells, and also have their bodies partially coiled. The heart is placed in the dorsal region. The skin of molluscs possesses a peculiar and characteristic covering. From a definite part of the body a larger or smaller fold of skin, called the "mantle," grows out, which encloses a space, called the "mantle cavity." In most molluscs this mantle secretes an external or internal calcareous mass. In this way a "shell" is developed (fig. 22, A, S; 23) which is usually external. This is the case with the edible and common garden snails. In other cases (cuttle-fishes) the shell is formed inside the mantle, or it may be replaced by a collection of calcareous granules (as in various slugs). In most molluscs the chief organ of locomotion is the so-called "foot" (fig. 24). This is a very muscular region of the body, covered by skin, and serving either for crawling (snails) or else for digging in the sand and even springing (bivalve molluscs). Its structure varies according to its function. The classes *Gastropoda* and *Lamellibranchiata* will be here considered.

CLASS I.—GASTROPODA (Snails and Slugs, Whelks, Cowries, Limpets, etc.).

The greater majority of the Gastropoda, excluding the whelks, cowries, limpets, etc., are marine. The snails and slugs, which will be considered here, belong to the *Pulmonata*. They possess a head which bears unjointed tentacles and also eyes, which in many cases are borne on the tips of pedicels. The foot serves for creeping, and is flattened in a sole-like way on its under-side (fig. 24). The mantle is generally small, and limited to the dorsal side of the animal. The usually spiral shell (fig. 23A) covers therefore only a small part of the body, but the rest of the body can also be mostly or entirely drawn back into it. Snails possess jaws, but the chief organ used in attacking plant structures is the swollen tongue covered by a rasping plate, on the surface of which regular rows of teeth are arranged. The rest of the tongue consists of muscle, and two small cartilages are also found within it. The teeth stick up when the tongue is protruded, and the whole apparatus forms a kind of rasp, by the backward and forward movements of which the food is reduced to small fragments. Marine snails breathe by gills, which are found in the mantle cavity (fig. 22kk), whilst most of the fresh water and all the land forms breathe by means of the inner wall of the mantle cavity, which thus serves as a lung. All true snails and slugs are hermaphrodite. The operculated land shells, such as *Cyclostoma*, *Helicina*, etc., are diœcius.

It is only amongst land snails and slugs that injurious kinds are found. Species of the genus *Helix* commit havoc in fruit culture and not improbably damage small trees.

Slugs are very injurious to agriculture in Europe and require to be studied in India. *Vaginulus* and *Girasia* are two Indian genera. Any kind of slug or snail may be harmful, especially if it attacks young plants. Some kinds, however, live chiefly in the forest, feeding upon toadstools and dung, perhaps also on bark and weeds. This is especially true of the larger kinds, but these also, if they multiply very rapidly, may do much damage in gardens, nurseries, etc. Slugs roll themselves up and hide beneath stones, etc., in dry weather, only feeding at night, so as to prevent themselves from being completely dried up. Fig. 24 shows a slug with body drawn up together as it appears when overtaken by the cold and fig. 27 one on the move. In wet weather they feed and crawl about during the day-time. A large number of eggs may be laid by an individual, and these eggs are often able to withstand great cold and dryness.



27. A slug (*Limax*).

28. A wood-boring Mollusc (*Teredo navalis*). A. The Teredo—*a*, valves of shell; *b* tube: *c*, *c*, siphons. B. Piece of the bamboo *Oxytenanthera albociliata* with living teredos, *a*, *a*, *in situ* in their borings. C. Same bamboo showing attacks of teredo. D. Section of a large Padauk pile badly attacked by the teredo.

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CLASS II.—LAMELLIBRANCHIATA (Bivalve Molluscs).

Headless. The mantle consists of two flaps, which secrete two shelly pieces (valves) movably united on the dorsal side (fig. 25). The foot is usually wedge-shaped. Respiration is effected by gills placed in the mantle cavity, which communicate with the exterior, either by the usual respiratory opening, or by a breathing tube. Most species are marine, but some live in fresh water. They are of no importance either in the forest or in agriculture. To this class belong the Oyster (*Ostrea edulis*), the Sea Mussel (*Mytilus edulis*), the tropical Pearl Mussel (*Meleagrina margaritifera*), the fresh water Swan Mussel (*Anodonta cygnea*) (fig. 25), the Nautilus (fig. 26), and the notorious Ship Worm, *Naustoria* (*Teredo*) *navalis*, which bores into wood, etc. The Ship Worm is a wood-boring mollusc which has been known for a very long period to cause great damage to wood placed in tidal waters. Its life-history is as follows :—

Life-history of the Teredo.

The Ship Worm or Teredo as it has been popularly known for many years past, bores holes into timber sunk into rivers and harbours within tidal areas. There are very few timbers which it does not entirely riddle within a few years. The molluscs attack the piles in company, driving elongate cylindrical holes into the wood, these tunnels have a longitudinal transverse or diagonal direction quite irrespective of the hardness or grain of the timber. The timber is only attacked between low and high tide levels as the *Nausitoria* only lives within this limit and it apparently prefers the side of the pile, etc., upon which the ebb tide impinges. Both teak and pyinkado and also bamboos are badly attacked by this mollusc in Burma. Fig. 28 shows the teredo worm, the worm *in situ* in a piece of bamboo and its tunnels in bamboo and pyinkado.

An interesting experiment recently made in Australia has shown that after a period of nearly seven years piles of the New South Wales turpentine wood (*Syncarpia laurifolia*) only had the sap-wood bored into about one inch, whereas the celebrated hard jarrah wood was entirely riddled within this period. The experiment was made at Port Hunter in New Zealand.*

PHYLUM VII.—CHORDATA or VERTEBRATA.

Bilaterally-symmetrical animals with certain parts of the body, such as the skeleton and musculature, segmentally arranged. Usually two pairs of limbs, never more, are present. There is a body cavity and a

* *Indian Engineering*, 1904.

ventral heart. The central nervous system is in the form of a continuous thick-walled tube along the dorsal side, generally enlarged anteriorly. Examples of this phylum are the fish, frog, lizard, bird, mammal.

This phylum is next in importance to the Arthropoda and will be considered in detail later on.

The following table shows shortly the position of the various groups of animals we have shortly considered in the Animal Kingdom:—

ANIMAL KINGDOM.

P rozoa.
Unic ar Animals.
mœba.

Metazoa.
Multicellular Animals.

Cœlenterata.
A simple digestive cavity.
Ex. Hydra, Coral, Jelly-fish.

Cœlomata.
A body cavity in addition to digestive cavity.
Ex. Worms, Leeches, Arthropods, Echinoderms, Molluscs. Vertebrata.

CHAPTER II.

SYSTEMATIC EXAMINATION OF THE PHYLUM ARTHROPODA.

The Arthropoda are bilaterally-symmetrical, segmented animals, the segments being variously modified. The limbs are jointed. The dermal skeleton is formed from a well-developed cuticle (chitin). A body cavity is present. The heart is on the dorsal side and the nervous system is situated along the ventral one. Highly specialised sight organs (compound eyes) are present.*

CLASSIFICATION OF THE ARTHROPODA.

The Arthropoda are divided into two groups according to the nature of the respiratory organs present:—

I. Breathe by *gills*, *lungsacks* (or occasionally *tracheæ* of a special kind).
  1. Elongate, cylindrical tracheæ of a special kind . . . Class 1.—ONYCHOPHORA.
  2. Have *antennæ* and breathe by *gills* . . . Class 2.—CRUSTACEA.
  3. Have no *antennæ* . . . . Class 3.—ARACHNIDA.

II. Breathe by *tracheæ* which are developed from dermal glands.
  1. Genital openings typically at posterior end of abdomen; latter without appendages . . Class 4.—INSECTA.
  2. Genital opening not far from anterior end of body; abdomen with appendages . . . Class 5.—MYRIAPODA.

CLASS 1.—ONYCHOPHORA.

This division includes only the genus *Peripatus*. In external appearance these animals are most like caterpillars. The body is elongate and cylindrical, the segments not externally demarcated The skin is granular and delicately streaked transversely. At the anterior end there is a pair of ringed tentacles and a pair of simple eyes. In the mouth there is a pair of jaw-like masticatory organs. The rest of the body consists of similar segments, each of which bears a pair of indistinctly jointed, stumpy limbs, ending in two claws. The alimentary canal consists of a straight tube and the anus lies at the

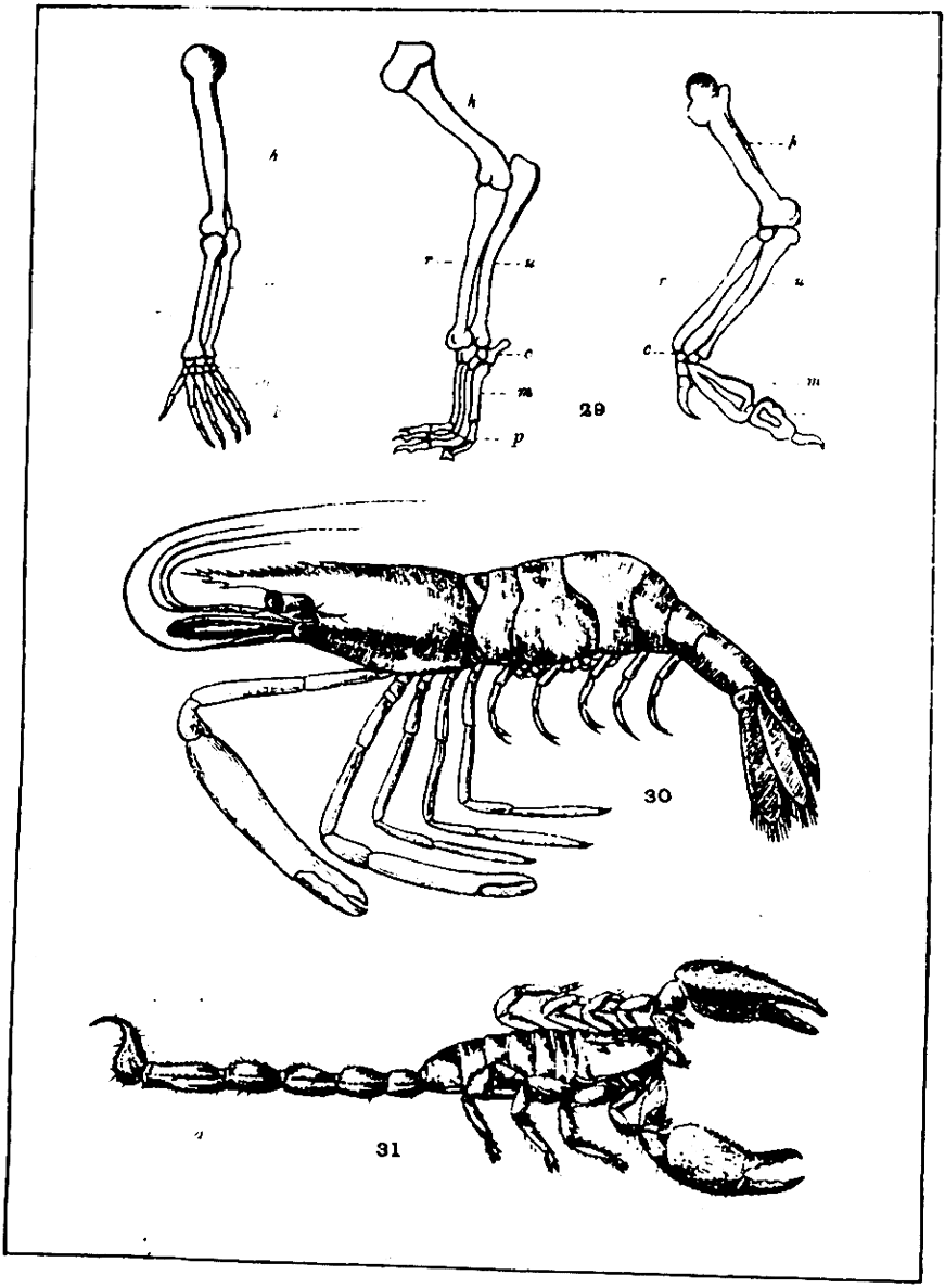
* This body cavity is not a true coelom, that species greatly reduced in Arthropods.

posterior end of the body. The respiratory organs consist of a well-developed system of air-carrying tubes which ramify in the body and open upon the surface in many delicate irregularly distributed respiratory apertures. The sexes are separate. The presence of these air-tubes is the reason for alluding to these animals in this work. In these tubes we see the first development of the tracheæ of the insect.

These animals live exclusively in warm climates in both Hemispheres, in damp places, in rotten wood, etc. It is not unlikely that several species at present unknown exist in Indian forests.

CLASS 2.—CRUSTACEA (Lobsters, Crabs, etc.).

The members of this class are commonly known as Crabs, Lobsters, Shrimps, Prawns, Barnacles, Woodlice, etc. They are nearly allied to the next class (the Spiders and Scorpions), but are distinguished by being adapted to an aquatic life, by having jointed appendages on the hinder segments of the body (abdomen), by the possession of two pairs of antennæ, and by the eyes being carried on stalks. As a class the Crustacea are distinguished by being usually furnished with branchiæ or respiratory organs adapted for breathing air dissolved in water, by having more than four pairs of legs, and by possessing a well-developed chitinous external skeleton. They also pass through a metamorphosis before reaching the adult stage. The body of a typical crustacean is composed of *twenty-one* distinct segments or somites placed one behind the other. These segments are distributed in three distinct divisions, known respectively as the "head," the "thorax," and the "abdomen" or tail. In very many cases, however, as *e.g.*, in the lobster and prawn (fig. 30), the fifteen segments belonging to the head and thorax are amalgamated together into a single mass termed the "cephalothorax" (fig. 30), thus leaving six segments for the abdomen. Each segment may be regarded as composed of a convex upper plate and a flatter ventral arch, and each may support a single pair of appendages. A certain number of the appendages on the anterior segments may be converted into masticulatory organs, biting jaws, and subsidiary jaws. A common crab has these parts. The cephalothorax here is covered by a great shield or *carapace* under which the gills are placed and the eyes are carried upon long, movable stalks.



29. A. arm of man; B, foreleg of dog; *c*, wing of a bird · *h*, humerus: *r*, radius, *u*, ulna; *c*, carpus; *m*, metacarpus; *p*, phalanges.

30. A Cray-fish.

31. An Indian Scorpion (*Scorpio swammerdami*); *a*, post-anal poison spine.

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The Crustacea form an extremely large group of animals divided into many orders. They are, however, of little importance to the forester.

CLASS 3.—ARACHNIDA (Spiders and Scorpions).

This class includes the Scorpions, Spiders, Mites, and Ticks, and is nearly related to the Crustacea, from which its members are distinguished by being strictly land animals, so that when distinct breathing organs are present, they are never in the form of gills, but always either lungsacks or air-tubes (*tracheæ*). None of this class have ever more than four pairs of legs and the segments of the abdomen never carry locomotive limbs of any sort. The eyes are sessile and are never supported upon stalks; the antennæ are converted into jaws or pincers (fig. 31); and the head is always amalgamated with the thorax so as to form a cephalothorax. The body is usually covered with chitin, but the skin at times remains soft. The mouth is situated at the anterior portion of the body, and in the higher forms is furnished with a pair of prehensile jaws, called *mandibles*, a pair of chewing-jaws, called *maxillæ*, and a lower lip.

ORDER.—SCORPIONIDÆ (Scorpions).

In the scorpions an upper lip is present as well. In both scorpions and spiders a stinging apparatus is present. In the scorpion the abdomen is divided into five segments and is continued into the cephalothorax without any well marked constriction. At the hind end of the body is a hooked apparatus furnished at the base with a poison gland (*cf.* fig. 31, a). It is with this that the scorpion stings and the poisonous fluid often has painful and dangerous effects, a cure for which is to rub in vinegar hard.

ORDER.—ARACHNIDÆ (Spiders).

In the spiders (fig. 32), on the other hand, the abdomen, which is soft, is joined to the cephalothorax by a constricted stalk or neck. Each mandible terminates in a sharp, movable hook, perforated by a canal which communicates with a poison gland situated near its base. By means of this poison apparatus spiders kill such animals as they capture.

Fig. 32 shows the spider *Thalassius Phipsoni* found in the Bombay Presidency.

ORDER.—ACARIDEA (Mites, Ticks).

The mites and ticks are small arachnids in which the abdomen is amalgamated with the cephalothorax to form a single mass (fig. 33). The mouth parts are adapted for piercing and sucking, but some mites have biting mandibles.

FAMILY.—*Acaridæ* (True Mites).

The skin is soft. No tracheæ; no eyes. Legs short, often with a sucker at the end (fig. 33, *mag.*). Many of the mites are parasitic. To this family belong the Cheese mite, Meal mite, the various Itch and Mange mites of man, horse, dog, pig, sheep, ox, fowl, etc.

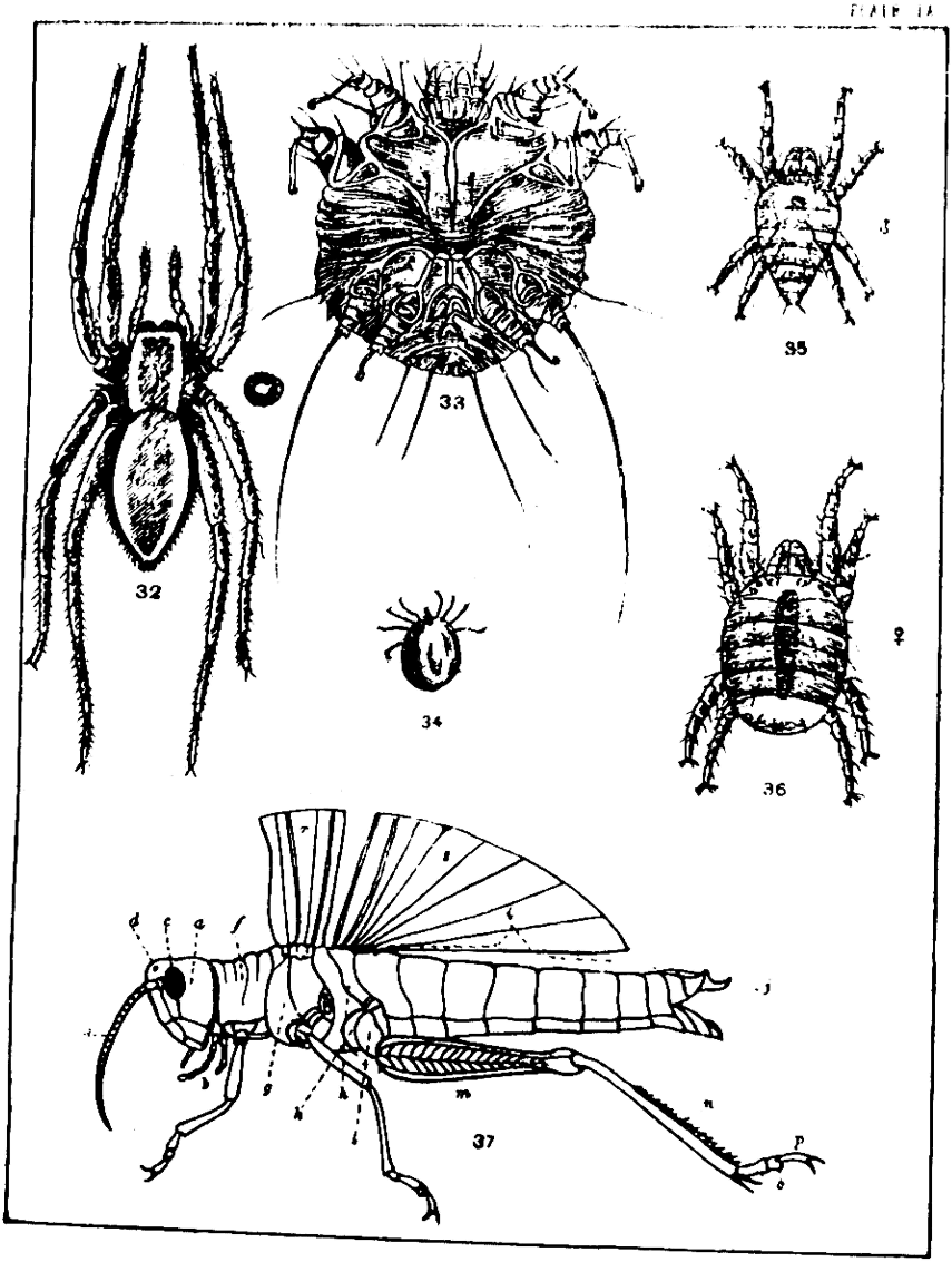
FAMILY.—*Ixodidæ* (Ticks).

Ticks (fig. 34, *mag.*) are generally rather larger than the mites of the last family. The skin is tough as leather. The front part of the body is covered by a hard shield above; the skin of the hinder part, though tough, is very extensible. The front end bears a sucking apparatus formed by the pointed jaws, and by its means the tick pierces the skin of man or animals and holds on fast.

Ticks are chiefly found in sandy soil, amongst bushes and shrubs or among herbs. As long as they remain on the ground they are tolerably small ($\frac{1}{10}$ inch) and very active. They creep up haulms and branches and rest in a suitable spot until a bird or mammal passes, when they attach themselves by their legs to its feathers or hair and bore into its skin with their sharp mouth parts. Having thus fixed themselves, they suck the blood of their temporary hosts. The walls of the stomach and intestine are exceedingly elastic, so that the tick swells till it becomes the size of a pea or even bean. When the tick has sucked itself as full as possible it withdraws its mouth parts from the skin of its host and lets itself fall to the ground, where it lies for many weeks without feeding. The small and feeble legs are not able to move the heavy, blood-filled body until the blood has been digested. Only the female acts in this way. The male is much smaller and never seems to attack mammals; its food is unknown. The presence of a large number of ticks on an animal is a serious matter, as they absorb a large amount of its blood; sheep and cattle daily attacked become thin. The dog tick also attacks man and will be found more especially prevalent in undergrowth.

FAMILY.—*Gamasidæ* (Beetle Mites).

These are temporary parasites on beetles, birds, and reptiles. Large beetles if looked at beneath, especially at the junction of the



32. *Thalassius phipsoni.*
33. A mite.
34. Common Indian Tick.
35, 36. Red spider mite, male and female.
37. North-West Locust. *a*, head ; *b*, mouth parts ; *c*, compound eye ; *d*, ocellus or simple eye ; *e*, antenna ; *f*, prothorax ; *g*, mesothorax ; *h*, metathorax ; *i*, segments of abdomen ; *j*, appendages ; *k* to *p*, leg—*k*, coxa (hip) ; *l*, trochanter ; *m*, femur (thigh) ; *n*, tibia (shank) ; *o*, tarsus ; *p*, claw ; *r*, front wing ; *s*, hind or under-wing.

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segments, will be seen to have minute mites on them. These are the beetle mites.

The fowl mite (*Dermanyssus gallinæ*) belongs to this family. It is about the size of a grain of sand and red or brown in colour. It lives on the fowls during the night hiding during the day on the perches or in nooks and crannies of the fowl-house and also in dung. The mites draw blood from the fowls producing itching and want of sleep, the result being that the birds grow very thin.

FAMILY.—*Trombidiidæ* (Running Mites).

Body four-cornered or longish oval; legs tolerably long, hairy; jaws claw or needle-shaped; surface of the skin velvety; colour reddish or yellowish. These mites run about with great rapidity on the ground, tree trunks, leaves, etc. Most species feed upon the juices which they suck from insects or from other arachnids.

The Plant Mite or 'Red Spider' (*Tetranychus telarius*).

Plant mites are often found in considerable numbers during summer, especially on the under-side of leaves and low growing plants. Occasionally they increase to such an extent as to prove a serious pest. They mostly remain fixed to the trees, sucking the sap. The so-called "red spider" of tea is one of these mites. It is ovoid, about one-fiftieth of an inch long; reddish (also yellowish or brownish) with a dark spot on each shoulder. The male and female are shewn, much magnified, in figs. 35 and 36. This mite commits a considerable amount of damage by sucking the sap from the young leaves and shoots and thus killing them and greatly diminishing the leaf area, and consequently the annual outturn from the garden.

Chapter III.

Class 4.—Insecta.

True insects are distinguished from the other arthropods by the fact that the three divisions of the body—the head, thorax, and abdomen—are always distinct from one another; there are never more than three pairs of legs in the adult, and these are borne upon the thorax; the abdomen has no locomotive appendages (*cf.* fig. 37). Respiration is effected by means of air-tubes or tracheæ, and in most insects a pair of wings are developed from the back of the second and third segments of the thorax.

Characteristic Features of Insect Life.

Insects form by far the larger part of the animals of the world; the number of species of insects is greater than that of all the rest of the animals of the earth. Owing to their small size they have been little studied and little is known either as to the number of species at the present moment living on the surface of the earth or on the subject of the habits of the greater number of the known species. The largest insects are scarcely bigger than a mouse or a wren, while the smallest are almost or quite imperceptible to the naked eye; in spite of this the larger part of the animal matter existing on the lands of the globe is probably contained in the form of insects. In the waters of the globe insect life is by no means so numerous. It practically only exists in any numbers in small collections of fresh water and then it may be for only a portion of the existence; in the larger bodies of fresh water insects live on the edges only and they are almost absent from the oceans.

Some insects form organised societies, a thing done by few other animals save man. We shall consider these later on.

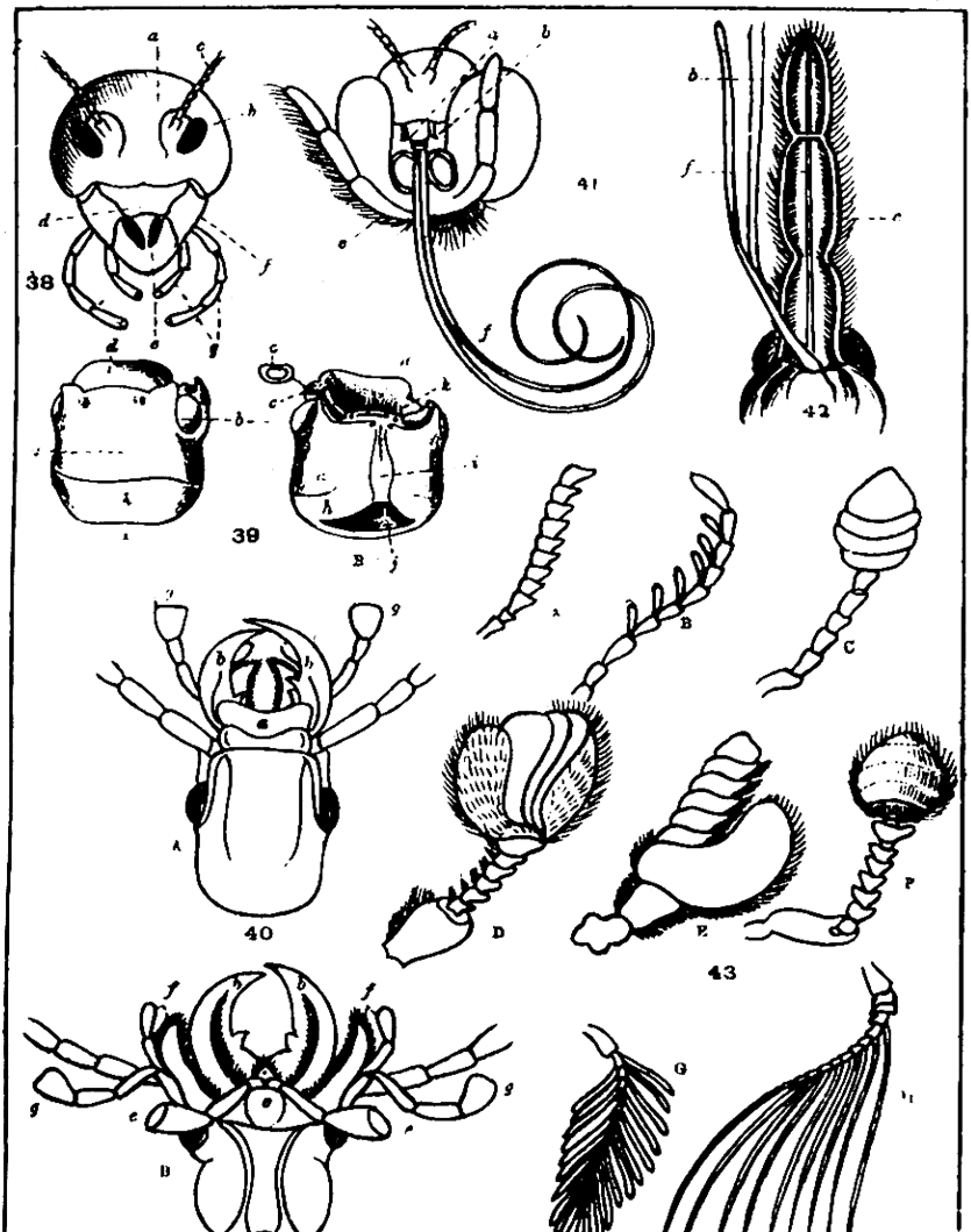
External Structure of an Insect.

The *integument* in insects is more or less hardened by the deposition on it of a horny material, called chitin, and the body is deeply cut

into segments (hence the name "Insect" from the Latin *insectus*, cut into). This chitin is usually regarded as an exudation. A film is poured out over the insect from the cells which secrete it; the film is at first soft and then hardens. Chitin does not grow or scale off. As arthropods grow in size they throw off their whole chitinous outsides. This is called moulting or ecdysis. There are never more than two layers of chitin on an insect at any one time. When the under layer has fully developed in size it is larger than the outer one and the latter is then thrown off. Chitin extends into orifices. About one-third of the anterior and posterior part of the gut is lined with chitin.

The *head* in insects is composed of several segments amalgamated together, and carries a pair of jointed feelers or antennæ, a pair of eyes, usually compound, and the appendages of the mouth (figs. 37a to e; 38). The head consists of three main definite areas: the epicranium, clypeus, and gula (figs. 38, 39, a, d, i). The clypeus is situated on the upper surface of the head-capsule in front; it bears the labrum (e), a sort of flap forming an upper lip. The labrum is usually possessed of some amount of mobility. The clypeus itself is excessively variable in size and form. The gula (*see* fig. 39, i) is a piece occupying a longitudinal and median position in the upper surface of the head; in front it bears the mentum (k) and extends backwards to the great occipital foramen (j). The epicranium forms the larger part of the head and is consequently most variable in shape and size; it usually occupies the larger part of the upper surface and is reflected to the under surface to meet the gula. The epicranium bears the antennæ. There is always a gap in the back of the head for the passage of the alimentary canal and other organs into the thorax; this opening is called "the occipital foramen" (fig. 39B, j).

The thorax is composed of three segments—the prothorax, mesothorax, and metathorax (fig. 37, f to h); the last two are usually immovable and united together, the prothorax being free and separately movable. Each division of the thorax has an upper region, called the notum, a ventral one called the sternum, and on each side a lateral region called the pleuron. These regions on the different segments of the thorax are distinguished by joining to their names the prefixes pro-meso-meta. Thus in the prothorax the dorsal surface is called the pronotum, the ventral the prosternum



38. Front of head of a Cricket.

39. Capsule of head of a Beetle, A, upper, B, under-surface. In all 3 figures; *a*, epicranium; *b*, compound eye; *c*, antenna; *d*, clypeus; *e*, labrum; *f*, base of mandible; *g* palpi; *h*, protocranium; *i*, gula; *j*, occipital foramen; *k*, mentum.

40. Head and mouth parts of a Ground Beetle (*Carabus*) enlarged, A, from above, B, from below. *a*, labrum; *b*, mandible; *f*, maxilla with palpi, *g*; *c*, labium with palp, *e*.

41. Mouth parts of a Butterfly.

42. Mouth parts of a Bug—names of parts as before. (After Nicholson.)

43. Antennæ of insects: A, serrate; B, pectinate; C, club-shaped; D, lamellate; E, clavate-lamellate; F, . riate-clavate; G, H, bipectinate.

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and each of the two sides the propleuron. Each of the segments of the thorax carries, in the perfect insect, a single pair of jointed limbs (37, k to p), so that there are three pairs in all. To the back of the two hinder segments of the thorax, in most insects, there are also attached two pairs of wings (fig. 37 r, s). In their typical form the wings are membranous expansions supported by more or less numerous hollow tubes, known as the "nervures." One or both pairs of wings may be wanting, and where both are present, the anterior pair may be much modified by the deposition of chitin in them. We shall consider this peculiarity later on.

The abdomen in insects is properly composed of eleven segments (37, i), which are usually more or less freely movable upon one another and which never carry locomotive limbs, as is so commonly the case in Crustacea. The extremity of the abdomen is, however, often furnished with simple jointed processes known as cerci (present in the cricket *cf.* fig. 49), or other appendages which are primarily connected with reproduction, but which are often converted into weapons of offence and defence (figs. 37, j; 85 d; 93). Of such a nature are the exserted "ovipositors" of Ichneumons, the stings of Bees and Wasps, saws or piercing instruments concealed within the apical portion of the abdomens of many insects, etc.

The organs of the mouth in insects are of considerable importance since the food, habits, and mode of life depend entirely upon the particular class of mouth parts present. Two chief types of mouth are recognisable, termed, respectively, the "masticatory" or biting which is the simplest form, and the "suctorial" or sucking mouth parts; insects fitted with the first feed upon hard substances, whilst those provided with the sucking mouth feed upon liquid food only. The biting mouth is present in the Orders Orthoptera, Coleoptera, Neuroptera, and Hymenoptera, and is seen to perfection in the Beetles, in which the following organs are present (*cf.* fig. 40 A, B) :—

(1) An upper lip or "labrum," which is attached below the front of the head, and is a broad, movable plate.
(2) A pair of biting-jaws or mandibles consisting each of a single piece. The inner surface forms the cutting edge.
(3) A pair of chewing-jaws or "first maxillæ" provided with jointed filaments, called the "maxillary palpi." The

maxilla consists of six to eight joints, of which the basal (cardo) is short, the second (stipes) large, and produced into two long lobes, the inner (galea) being usually fringed with stiff setæ along its outer edge, the other (lacinia), in several forms, consisting of two joints. The rest of maxilla, consisting of 4-6 joints, forms a curved palp.

(4) A lower lip or "labium," the second maxillæ, which also carries a pair of jointed filaments known as the "labial palpi." The second maxillæ are similar to the first, but are distinguished by the fact that the two cardines are always fused to form a single plate, the mentum; the stipes, too, are more or less completely fused and the lobes are often considerably modified as compared with the first maxillæ and called glossæ or paraglossæ; the palps are like those of the first maxillæ, but never consist of more than four joints.

In the typical suctorial mouth, as seen in Butterflies and Moths (fig. 41), the following is the arrangement of parts. The upper lip and mandibles are quite rudimentary; the first maxillæ are greatly lengthened, and form a spiral tube fitted for sucking up the juices of flowers; and the labial palps are much developed, and form two hairy cushions, between which the trunk can be coiled up when not in use.

In many insects the organs of the mouth, whilst being essentially adapted for suction, are also adapted for piercing solid substances, such as the skin of animals or the stems of plants. In these the lower lip forms a kind of sucking-tube or sheath, within which are contained the first maxillæ and mandibles, which are modified so as to form piercing organs or lancets (fig. 42). This is the mouth present in bugs, plant lice and scale insects (Order Hemiptera).

In the common Bee we get a biting mouth and sucking mouth combined. The mandibles or biting-jaws are retained, to enable the honey-comb to be manufactured, and there is also a tubular trunk fitted for sucking up the juices of flowers (fig. 104). In the Butterflies, also, in which the mouth of the adult is strictly adapted for suction, the caterpillar is furnished with a biting mouth, so that it can feed upon leaves, wood, and other solid substances.

From the head arise a pair of antennæ or feelers (fig. 37 c), which either consist of a few well-developed joints, or of a large number

of very short ones. The form of the antennæ is very varied (*cf.* fig. 43, A to H); at the simplest they are filiform or bristle-like, but they are sometimes moniliform, *i.e.*, are much constricted at the joints; or they may be pectinate, the joints being produced on one or on both sides (in the latter called bi-pectinate) into processes, serrate, or various forms of clavate (club-shaped), the club, when consisting of long joints on one side, being called lamellate. The antenna is sometimes elbowed or geniculate as seen in the Stag Beetle and various Bark Beetles. These variations in form of the antennæ are important, as divisions of the orders are at times based on them, as we shall see under Coleoptera, etc. The other appendages of the head are the eyes. These may be compound (fig. 37 c) or simple (d). The compound eye is composed of numerous six-sided lenses, united together, and each supplied by a separate nervous filament. From 20 to as many as 8,000 of these lenses have been counted, the latter in one of the eyes of the common Cockchafer Beetle, and this number is sometimes greatly exceeded. Besides the compound eyes there are sometimes simple eyes, identical in structure with the single lenses of the compound eyes; and in rare cases these are the only organs of vision.

The appendages of the thorax are the wings and legs (fig. 37 r, s and k to p.) The two pairs of wings may be identical in form or they may differ from one another both in size and consistency, the upper being hard and horny and serving as a shield or 'elytra' for the lower ones, which are then folded up between them and the body. During flight the wings are spread laterally, but when at rest they are turned backwards over the body. Wings may be rudimentary or absent altogether. The only great order of insects provided with a single pair of wings is the Diptera, (*cf.* fig. 288) and in them the metathorax possesses, instead of wings, a pair of little capitate bodies, called 'halteres' or poisers. In the great Order Coleoptera or beetles the anterior wings are replaced by a pair of horny sheaths that close together over the back of the insect, concealing the hind wings, so that the beetle may look like a wingless insect (*cf.* fig. 130); these elytra take no part in flight, being merely opened to allow the under wings to be unfolded. In the Orthoptera the front wings also differ in consistence from the other pair over which they lie in repose, and are called *tegmina* (*cf.*

52, 53, 59). In the Order Hemiptera a portion only of the upper wings may be horny, the apical part and the lower wings being membranous (*cf.* fig. 294). There are other insects in which the wings exist in a more or less rudimentary condition and are never used for flight (*cf.* fig. 56).

The other appendages of the thorax are the legs. The leg is divided into the following parts (*cf.* fig. 37 k to p.): ***coxa, trochanter, femur, tibia***, and ***tarsus***; each of the four first consists of a single joint only, while the tarsus has generally several joints. The coxa and trochanter are usually short, the coxa being the joint which joins the leg to the body, the femur and tibia long, the former being thicker than the latter; at the lower end of the tibia there is generally a movable pair of spines (spurs). The tarsus in many insects consists of five joints or the number may be fewer, and we shall see later on that the Order Coleoptera is divided up into divisions by the number of tarsal joints present in the insects of the order. The tarsus usually bears at its tip two movable hooks, the *claws*. The legs are true locomotive organs; in walking the animal rests on the lower side of the tarsus, which is often hairy; in the first pair of legs the foot is forwardly directed, in the last pairs backwardly. In many forms the legs or some of them have other functions save those of walking only. The first pair in the Cockchafer serve not only for walking, but also for digging; in others the legs are so modified for use in a special way that they have lost their true function, *i.e.*, that of walking. The first pair of legs in the male Cricket, for instance, is only used for digging, the same pair in Water-scorpions for organs of prehension, the last pair in the Locust form a springing apparatus, whilst in *Dytiscus* it is used for swimming purposes.

The other external organs of the body to be noticed are a series of apertures used for the admittance of air to the respiratory system placed along the sides of the body of the insect. They are usually quite visible in the larva, but more or less concealed in the perfect insect. They are called "spiracles" or "stigmata (fig. 46)." They vary in size. The largest are to be found on the prothorax of a Cerambycid Beetle.

The anal appendages have been already considered.

Internal Structures.

Muscles.—The muscular system of Insects is very extensive. The structure of the muscles does not differ much from that of vertebrate animals. The force brought into play by the contractions of Insects' muscles is very great.

3. *Digestive.*—The mouth in the biting insects leads into a membranous and often folded cavity (*cf.* fig. 44), termed the "crop," by way of the œsophagus or gullet, a ; from this the food passes to a second muscular cavity or "gizzard." The gizzard is adapted for crushing the food and often has plates or teeth of chitin developed in its walls. It is succeeded by the true digestive cavity, which is termed the "chylific stomach." This stomach consists of two parts, an upper wider portion and a lower narrower portion. Below this there is an intestine of variable length. The commencement of the gullet is furnished with glandular appendages, which perform the functions of salivary glands. Into the intestine open a variable number of convoluted tubes which are known as the "Malpighian tubes," after their discoverer, Malpighi, and which function like the kidneys of higher animals.

6. *Circulation.*—The circulation in insects is mainly carried out by a long contractile tube placed along the back, and termed the "Dorsal vessel or heart (fig. 45)." The blood collected from the various tissues and organs of the body enters the dorsal vessel from behind, and is driven forward to the anterior extremity of the body. The heart lies in a spacious cavity, the *pericardium* (fig. 45, h). The heart and the tubular expansion at its anterior end are the chief vessels.

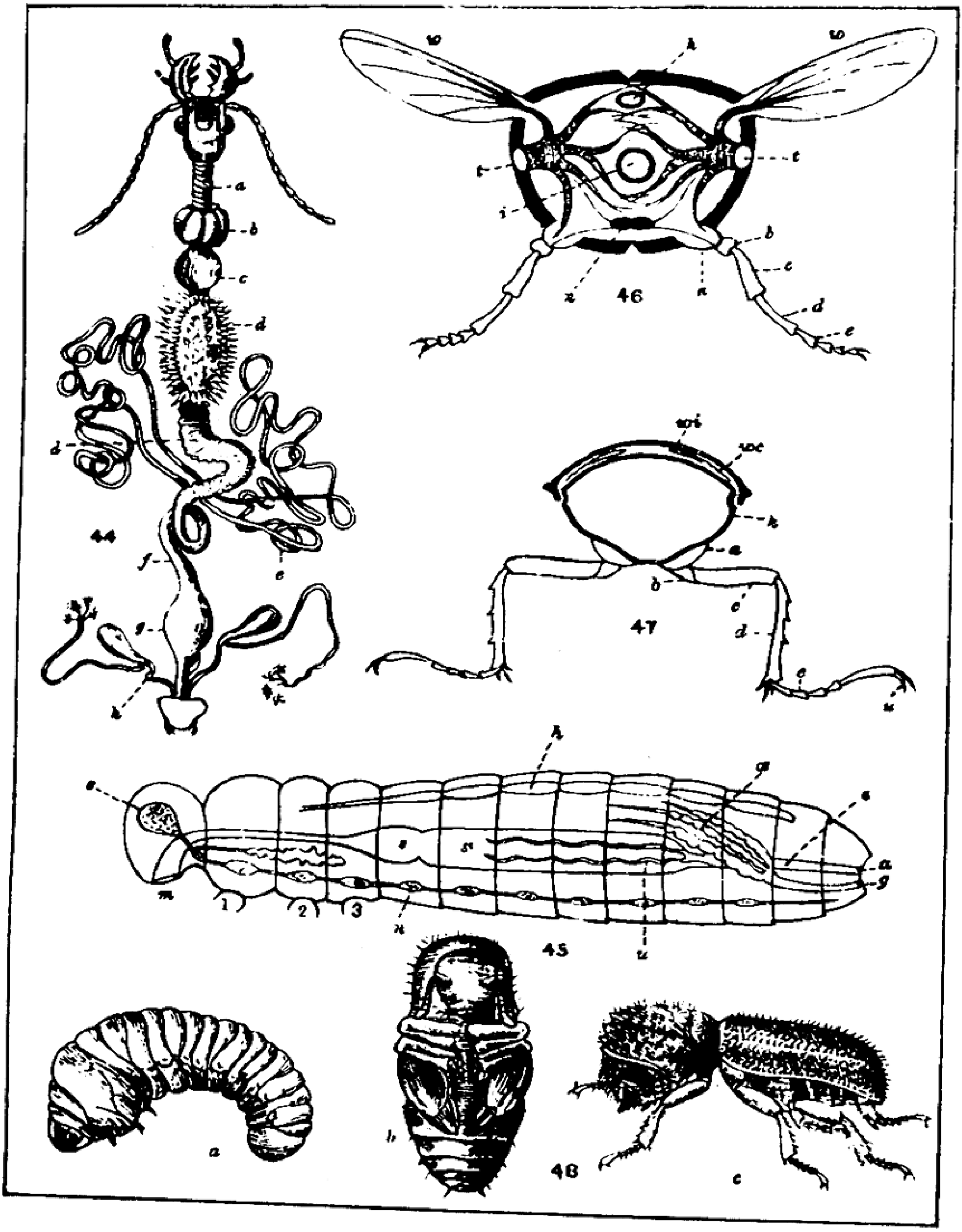
5. *Respiration.*—Respiration is effected by means of air-tubes or tracheæ which commence at the surface by a number of apertures or spiracles, and branch repeatedly as they proceed inward through the tissues. They have the same structure as in the *Arachnida*, consisting of membranous tubes strengthened by means of a spirally coiled filament of chitin. The tracheæ are prolonged into the wings and other organs. Fig. 46 shows a transverse section through the thorax exhibiting the tracheal openings one on either side and the air tubes prolonged into the wings.

2. *Nervous.*—The nervous system in insects, though sometimes somewhat modified, consists of a ventral chain of double ganglia, tra-

versed in front by the gullet. There is an enlarged cerebral ganglion in the head (fig. 45 c, n). The organs of sense are the eyes and antennæ, which have been already described. The feelers or antennæ are attached close to the eyes. They appear to be certainly organs of touch, but they may be connected with other senses as well, and especially with that of hearing.

4. *Excretory.*—The Malpighian tubes (already mentioned) are delicate unbranched, highly-coloured, white, yellow, brown, or green tubes opening into the intestine (fig. 45); they are usually only few in number, four to six, when they reach a considerable length; in the Hymenoptera and some of the Orthoptera, however, there is a much larger number of shorter tubes. These constitute the excretory apparatus.

7. *Reproduction.*—The sexes in insects are distinct and most of them are oviparous. The reproductive and gut organs are distinct and open separately on the external surface. Generally speaking, the young insect is extremely different in external characters from the adult, and it requires, before reaching maturity, to pass through a series of changes which collectively constitute what is called "metamorphosis." In some insects, however, there is no metamorphosis, and in some the changes which take place are less complete than in others. This character is made use of in the classification of insects. The ♀ possesses a pair of ovaries (fig. 45). At times the posterior end of the abdomen of the ♀ is modified in some way to assist in depositing the eggs, *e.g.*, the ovipositor of the locust consisting of complicated knife-like or dagger-shaped blades, or there may be a sting as in Hymenoptera (*cf.* fig. 96) on the last abdominal segments, which are then thin and elongate; or the last few segments may be telescoped and serve in this capacity, as in Diptera and others. Many species of insects are remarkable in that a large number of individuals remain sterile throughout life, and thus take no part in the propagation of the species; such insects are generally incompletely developed females as in Bees and Ants, or both males and females as in Termites (white-ants). The occurrence of such sterile individuals is associated with the fact that these insects live in colonies and are social. The care of the young is relegated to these sterile insects.



44. Alimentary canal of a Beetle (*Carabus*). *a*, Æsophagus; *b*, crop; *c*, gizzard; *d*, wide portion of chylific stomach; *d'*, narrow portion of chylific stomach; *e*, malpighian tubes; *f*, intestine; *g*, cloaca; *h*, anal glands. (After Dufour).

45. Diagrammatic section of an insect: 1—3, 1st to 3rd pairs of legs cut away. *a*, anus; *c*, cerebral ganglion; *s*, *s'*, stomachs; *g*, genital aperture; *h*, heart; *k*, crop; *m*, mouth; *n*, ventral ganglion; *sp*, salivary gland; *u*, malpighian tubule; *æ*, ovary. (After Boas).

46. Ideal transverse section of an insect: *h*, heart; *i*, intestine; *n*, ventral nerve-cord; *t*, *t*, stigmata leading into the branched tracheal tubes; *w*, *w*, wings; *a*, coxa of leg; *b*, trochanter; *c*, femur; *d*, tibia; *e*, tarsus. (After Pachard).

47. Transverse section through the thorax of a beetle (diagr.): *we*, elytra; *wi*, wings; *h*, body wall; *a*, coxa; *b*, trochanter; *c*, femur; *d*, tibia; *e*, tarsus; *f*, claw. (After Boas).

48. *Dinoderus minutus*: *a*, larva; *b*, pup ; *c*, beetle.

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Exceptional Phenomena.—The following terms require explanation:—

Parthenogenesis (Lat. *parthenos*, a virgin; and *gignomai*, to be born).—Means the production of new individuals from virgin females by means of ova without the intervention of the male.

Alternation of Generations.—The alternation of a parthenogenetic generation with a true sexual generation—

Mimicry.—When an animal counterfeits the shape, colouring, etc., of another, whether for protective or other reasons, it is said to mimic it.

Metamorphosis.—The abrupt changes of form which certain animals undergo in passing from their younger to their fully grown condition.

Metamorphosis may be complete or incomplete. Metamorphosis is said to be complete when the larva and the adult are entirely unlike one another and the larval stages exhibit, externally, no gradual approach to the adult form, and also--and this is the most important characteristic—that between the larval and adult stages a special period of probation intervenes, called the pupal stage, during which the animal does not feed and is generally quiescent. During this stage the series of changes which turn the larva into a butterfly, beetle or other mature form take place, and this form issues generally by throwing off the pupal skin. The stage of larva, pupa, and imago passed through by the beetle *Dinoderus minutus*, the bamboo shot-borer, (shown in fig. 48 a, b, c,) is an example of this. The larva, however, is completely different in form, compound eyes replaced by a group of ocelli; antennæ short and consist of few joints; mouth parts consist of a biting apparatus, legs short, and with fewer joints and more uniform than in adult; wings absent; thorax small, abdomen large, nervous system, and food are also different. In incomplete metamorphosis, on the other hand, the newly hatched larva differs chiefly from the adult or *imago* in that it is apterous, *i.e.*, wingless, as, for instance, in the case of the young of a locust. In other respects the differences are slight, the number of joints of the antennæ may be fewer, the head relatively larger than in the adult, and so on. The transition from the first larval stage to the adult occurs gradually; wings begin to appear,

small at first but increasing with each moult, until they are perfect after the last one. At the same time the other portions of the body have attained their definite form (*cf.* fig. 49 a, b, c, d.) This can be easily traced in the case of the common Indian locusts and grasshoppers and in the field cricket *Brachytrupes achœtinus* (fig. 49). In others, however, the changes in form are much greater, attributable to differences in habits. These changes are well marked in the Dragon-flies which are aquatic as larvæ and terrestrial as adults: in the larvæ of these forms the tracheal system is closed and they breathe by means of tracheal gills. In these the ordinary opening of the tracheæ is closed by a membranous appendage with a large surface and the larva obtains its oxygen from the water by endosmosis; in the adult, on the contrary, we have the usual tracheæ; at the last moment these special modifications disappear and with the fully developed wings growth ceases.

Geological Record.—Although insects have been inhabitants of the earth for a very long period, the record of their former presence is as yet a very imperfect one. The remains of creatures that can be referred to the class Insecta have been found, it is said, in Silurian strata; only one or two of these very early forms are known, and they were winged. In the strata of the Carboniferous epoch numerous insects have been detected, both in Europe and North America. In the more recent rocks insect remains become comparatively numerous, and in the Mesozoic strata forms that can be satisfactorily referred to existing orders have been found. From the evidence of the Tertiary Rocks, it is concluded that insects were more numerous in species at that time than at the present day. In these rocks the present day gall-making insects have been found numerously and their galls as well. It may be mentioned that fossil insects are chiefly determined from their wing remains, which are often surprisingly perfect.

CLASSIFICATION.

The great groups of Insects are called Orders, and nine of these are recognised here, although two of them will be little more than mentioned. The classification of these orders depends on—

(1) the nature and number of the wings present;
(2) the form of the mouth parts, whether biting, sucking, or both;

(3) the nature of the metamorphosis, whether complete or incomplete

ORDERS.

1. *Aptera* (*a*, without; *pteron*, a wing—wingless insects*). Mouth mandibulate (biting) or very imperfectly suctorial Metamorphosis incomplete.
2. *Orthoptera* (*orthos*, straight; *pteron*, a wing—straight-winged). Four wings are present, the front pair being coriaceous (leather-like), usually smaller than the other pair, which are of more delicate texture, and shut up in repose after the manner of a fan. Mouth mandibulate. Metamorphosis incomplete.
3. *Neuroptera* (*neuron*, nerve; *pteron*, a wing—net-winged). Four wings of membranous consistency, frequently with much net-work in them; the front pair very little, if at all, harder than the other pair; the latter with but little or no fan-like action in closing. Mouth mandibulate. Metamorphosis complete.
4. *Hymenoptera* (*humen*, membrane; *pteron*, a wing—joined winged). Four wings of membranous consistency; the front pair larger than the hind, which are always small and do not fold up in repose. Mouth mandibulate, sometimes provided also with a tubular proboscis. Metamorphosis complete.
5. *Coleoptera* (*koleos*, sheath; *pteron*, a wing—sheath-winged). Four wings, the upper pair shell-like in consistency, and forming cases, which meet together over the back in an accurate line of union so as to entirely lose a wing-like appearance, and to conceal the delicate membranous hind pair. Mouth mandibulate. Metamorphosis complete.
6. *Lepidoptera* (*lepis*, scale; *pteron*, a wing—scale-winged). Four large wings, covered with scales. Mouth suctorial. Metamorphosis complete.

* All wingless insects do not, however, fall within the limits of this Order.

7. Diptera (*dis*, double; *pteron*, a wing—two-winged). Two membranous wings. Mouth suctorial, but varying greatly. Metamorphosis complete.
8. *Thysanoptera* (*thusanos*, fringed; *pteron*, a wing—fringe-winged). Four very narrow fringed wings. Mouth imperfectly suctorial. Metamorphosis incomplete.
9. *Hemiptera* (*hemi*, half; *pteron* a wing—half-winged). Four wings; the front pair either leather-like with upper portion more membranous or entirely parchment-like or membranous. Mouth perfectly suctorial. Metamorphosis incomplete.

It must be borne in mind that numerous exceptions exist to these characters in most of the great Orders; for instance, wingless forms are not by any means rare in several of the Orders.

The next chapters will be devoted to a detailed description of these Orders.

Chapter IV.

Order I.—Aptera.

Small insects with a weak outer skin ; 3 pairs of legs, no wings, and long or moderately sized antennæ. They are the most primitive forms of insects. The order includes the sub-order *Thysanura* to which the common so-called fish-insect of India, a species of *Lepisma*, belongs (fig. 50). Some of the Thysanura live under the bark of dried and decaying trees or in decaying wood. More rarely, as in the case of the fish-insect, they prefer warm and dry localities. The fish-insect is well known in India and perhaps commits most damage in libraries and to pictures, although it will feed upon all sorts of substances. In the case of pictures the fish-insect feeds upon the saccharine material used in mounting the picture. Such should always be mixed with arsenic, or naphthaline powder should be dusted over the picture back. Book cases should be finely powdered with naphthaline to preserve the books, and record rooms could be with advantage always treated in this way.

Order II.—Orthoptera.

Insects with mouth parts conspicuous, formed for biting, the four palpi very distinct, the lower lip longitudinally divided in the middle. The upper wings of parchment-like consistence called "tegmina"; in repose they are closed on the back of the insect so as to protect it and the lower wings (*cf.* figs. 52, 53, 59) ; the latter of more delicate consistency, large, and furnished with fan-like nervures, intersected by smaller cross ones, joining together and forming a net-work in the wing (*cf.* fig. 55) ; they are generally covered over in repose by the upper wings. The mode of growth of each individual is a gradual increase of size, the wings being developed during the last moults, *i.e.*, the metamorphosis is incomplete. Species in which the wings are absent or rudimentary are found in the order.

The Orthoptera are insects of comparatively large size, and some of the largest of existing insects belong to the Order. It includes earwigs, cockroaches, praying-mantis, stick-and-leaf-insects, grasshoppers, locusts, and crickets.

The insects often spend some time in the egg stage. The wings are never present when the larva is first hatched, but appear subsequently and increase in size at the moult; the form and proportion of the segments of the body, especially of the thorax, undergo much change; changes in colour occur at the moult and the integument becomes harder in the adult condition.

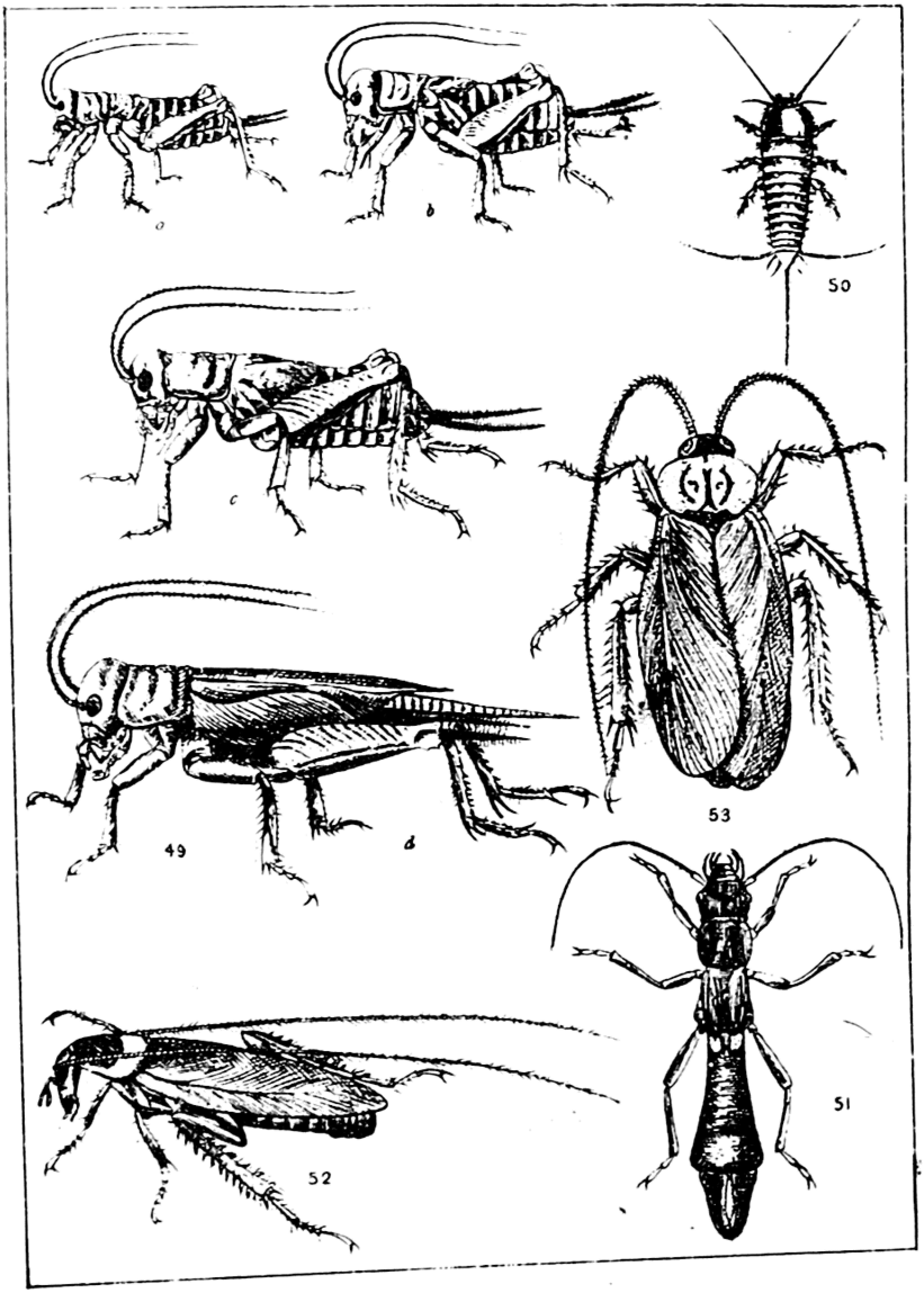
Many of the Orthoptera do not possess wings fit for flight and flight appears to be of minor importance in the Order; in many cases where the wings exist they are purely musical organs and are not of any use for flight. The front wings, which are hard and of parchment-like consistency, are never used for flight. The musical powers of the Orthoptera are confined to the Saltatorial group of the families; the Cursoria are dumb or nearly so. In this latter series the wings have little value for flight and are simply used for purposes of adornment or concealment, especially in the Phasmidæ and Mantidæ. Here the upper wings frequently exhibit a great resemblance to vegetable structures, such as stems, leaves, etc., (*cf.* fig. 58) the veins and shape of the leaf being copied with remarkable accuracy in the upper wing of the insect. Contrary to the usual conditions in insects, the ♀ is often more remarkable than the ♂ in colouring. The musical powers are, however, always found in the ♂ and serve doubtless for attracting the ♀.

The eggs of the Orthoptera are deposited in capsules or cases (*cf.* fig. 57); these capsules may contain only one egg or a great many. The species existing is now estimated at 10,000, but this is probably far under the number, as the small tropical forms have never been properly collected.

We shall treat the Order as comprising seven families:—

Series *Cursoria*: hind legs but little different from the others.

1. *Forficulidæ* (Earwigs).—Upper wings short, lower wings complexly folded; body armed at the extremity with a strong forceps.
2. *Blattidæ* (Cockroaches).—Coxæ of the legs large, exserted, protecting the lower part of the body.
3. *Mantidæ* (Praying Insects).—Front legs very large, raptorial, armed with spines.
4. *Phasmidæ* (Stick Insects).—Mesothorax large as compared with the prothorax.



49. *Brachytrupes achatinus.* *a, b, c,* young stages ; *d,* full-grown insect.
50 *Lepisma sp.* (Fish-insect).
51. *Forficula sp.*
52 *Periplaneta americana* (common cockroach).
53 *Blatta sp.*

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Series *Saltatoria*: hind legs elongate, formed for leaping, their femora usually thickened.

5. *Acridiidæ* (Locusts).—Antennæ short, not setaceous, of not more than 30 joints; tarsi three-jointed.
6. *Locustidæ* (Grasshoppers).—Antennæ long, setaceous, composed of a large number of joints; tarsi four-jointed.
7. *Gryllidæ* (Crickets).—Antennæ very long, setaceous; tarsi two- or three-jointed. Outer part of upper wing bent over and folded vertically against side of insects.

Series.—Cursoria.

Hind legs but little different from the others.

FAMILY I.—*Forficulidæ* (Earwigs).

These insects are distinguished by having a horizontal head and very short wing-covers, *i.e.*, upper wings, which do not extend beyond the insertion of the hind legs and repose flat on the back, meeting together in a straight line along the middle. The lower wings, which are very large and ear-shaped, are folded beneath the upper, projecting at the lower end in small slips from beneath them (fig. 51). These small slips are often hardened to the same consistency as the upper ones. This formation of the wings is characteristic of the family when wings are present. The end of the body is furnished with a pair of large callipers.

This family is not of great importance to the forester so far as is at present known as regards damage done by it in the forest. Some species may, however, prove of some service in preying upon noxious pests. Whilst visiting the sandal wood areas of North Coimbatore in Madras, it was noticed that a large grey earwig (fig. 51) was almost invariably present in the old galleries of a longicorn beetle which bores into the stems of saplings and tunnels down their centres. These tunnels were also used as a home by a species of white-ant, which was tunnelling through the wood of still living trees. The earwig was probably predaceous upon the termites and their larvæ.

FAMILY II.—*Blattidæ* (Cockroaches).

Insects with the head deflexed and hidden from above in repose, the lower end being directed backwards. The coxæ are very large

free, and entirely cover the under surfaces of the three thoracic segments and also the base of the abdomen. The tegmina (*cf.* fig. 53) and wings are very variable and may be absent. The three pairs of legs resemble one another very closely.

The cockroaches are amongst the oldest forms of insect life known. In the Carboniferous epoch they existed in considerable numbers and variety, and at the present day have much the same appearance. The group contains about 800 species divided into 10 genera. The head is bent vertically downwards so that the mouth is on the under part. There is a gap in the compound eye from which the base of the antenna springs. Antennæ are bristle-like, long and flexible, containing from 75-90 joints and are longer in ♂ than in ♀. Their function is supposed to be that of smelling. Cockroaches have strong running legs with large femurs. The thorax has a movable division between the pro-and meso-thoracic segments. Tarsus is five-jointed and has a soft pad between the claw. Fore wings partially overlap. The abdomen is flattened and differs in the two sexes. In ♂ 10 segments are visible, whereas in the ♀ only 7 are visible, the 8th and 9th being seen if the 7th is lifted up. From the sides of the 10th segment spring the cerci, small, flat, compressed processes usually distinctly jointed, and present in both ♂ and ♀. In the ♀ in addition there are two styles on either side of the cerci. The eggs are laid in a capsule formed inside the body of the female. This capsule is deposited in a suitable place and the young cockroaches hatch out.

These insects are common in houses, in vessels employed in river and ocean traffic, etc. They may be often found in rotten stumps in the forest, and many of these forest species would appear to be wingless; a flat black species, is common in such localities in the North-East Himalayan forests and probably throughout the Himalayas. As a family their food is of a very mixed nature.]

Periplaneta americana (fig. 52) is a cockroach of world-wide distribution and is very common in Indian houses.* It is to be found in the warmer parts of the country throughout the year. Blatta sp. (fig. 53) is an Indian species found at Johore.

* *Treatment.*—This cockroach may be got rid of by preparing a mixture of finely powdered chocolate and borax and dusting it into the corners of rooms and crevices, where the insects hide. The mixture must be well made so that with each particle of chocolate, of which the insects are very fond, they will get a particle of the borax which is poisonous to them. The mixture is cheap and non-poisonous to man.

FAMILY III.—*Mantidæ* (Praying Insects).

The *Mantidæ* are allied to the cockroaches, but differ in various respects. The body is, on the whole, more elongate, the prothorax being very long. The first pair of legs are prehensile with large coxæ and strong femurs (thighs), each provided on the inner side with two rows of spines; the tibiæ (shank) are also furnished with two inner rows of spines, and they can be folded back upon the femurs; with these appendages the animal seizes its prey, which consists of other insects. The second and third pairs of legs are simple. In the peculiar position in which these creatures rest their fore legs are held up in the attitude of prayer whence they get the name of 'praying mantis.' The ova are attached to plants in groups, surrounded by a yellowish or greenish exudation which hardens. These capsules are found plentifully in low jungle and grass areas. Fig. 54 shows an egg-capsule of the mantis *Deiphobe ocellata* attached to a twig, and fig. 55 a male of the same insect from Kulu. The eggs last deposited are said to hatch first.

Many of the insects of this family mimic to a certain extent the objects amongst which they live. A mantis of Eastern Bengal, called *Gongylus gongyloides*, has its under-surface resembling the pink corolla of a papilionaceous flower. It usually hangs head downwards amongst green foliage simulating a flower, and insects flying to and settling upon it are seized and consumed. This insect has been known to science for upwards of three centuries, and yet very little is known about the various stages of its life-history, a case well illustrating the remarks already made upon this subject.

The *Mantidæ* are not of forest importance, although they are common enough, and are often attracted to the lighted bungalow at night and may be watched stalking their prey or waiting motionless on the dining table or on the whitewashed walls.

FAMILY IV.—*Phasmidæ* (Stick and Leaf Insects).

The wings are rudimentary and legs very long. The prothorax is very short and the meso- and meta-thorax unusually long (*cf.* fig. 56). The *Phasmidæ* are inhabitants of warm countries; they mimic dry sticks and leaves in a marvellous manner. Their eggs have a

remarkable resemblance to seeds of plants (fig. 57). They are dropped singly by the insect at random on the ground, being enclosed in a capsule. Fig. 57 shows the eggs of the stick insect *Lonchodes virgens*, an insect nearly 18 inches in length, living in Assam.

Stick insects have the power of renewing a lost leg, the mutilated limb being replaced by one as perfectly functional as the original. The right front leg in fig. 56 is a renewed one. The males and females often differ entirely in appearance.

The genus *Bacillus* is wingless, the elongate body and long legs looking like a dry branched twig or piece of stick. This genus feeds upon foliage, at times doing very considerable defoliation in Australia. They are, however, very sensitive to cold, and frost will always put an end to them there. In Fiji and the Friendly Islands a species of *Lopaphus* eats the leaves of the cocoanut, and at times causes such a scarcity of food that it becomes necessary to take measures to destroy it. Fig. 56 shows an Indian species, *Bacillus artemis*, from the Naga Hills.

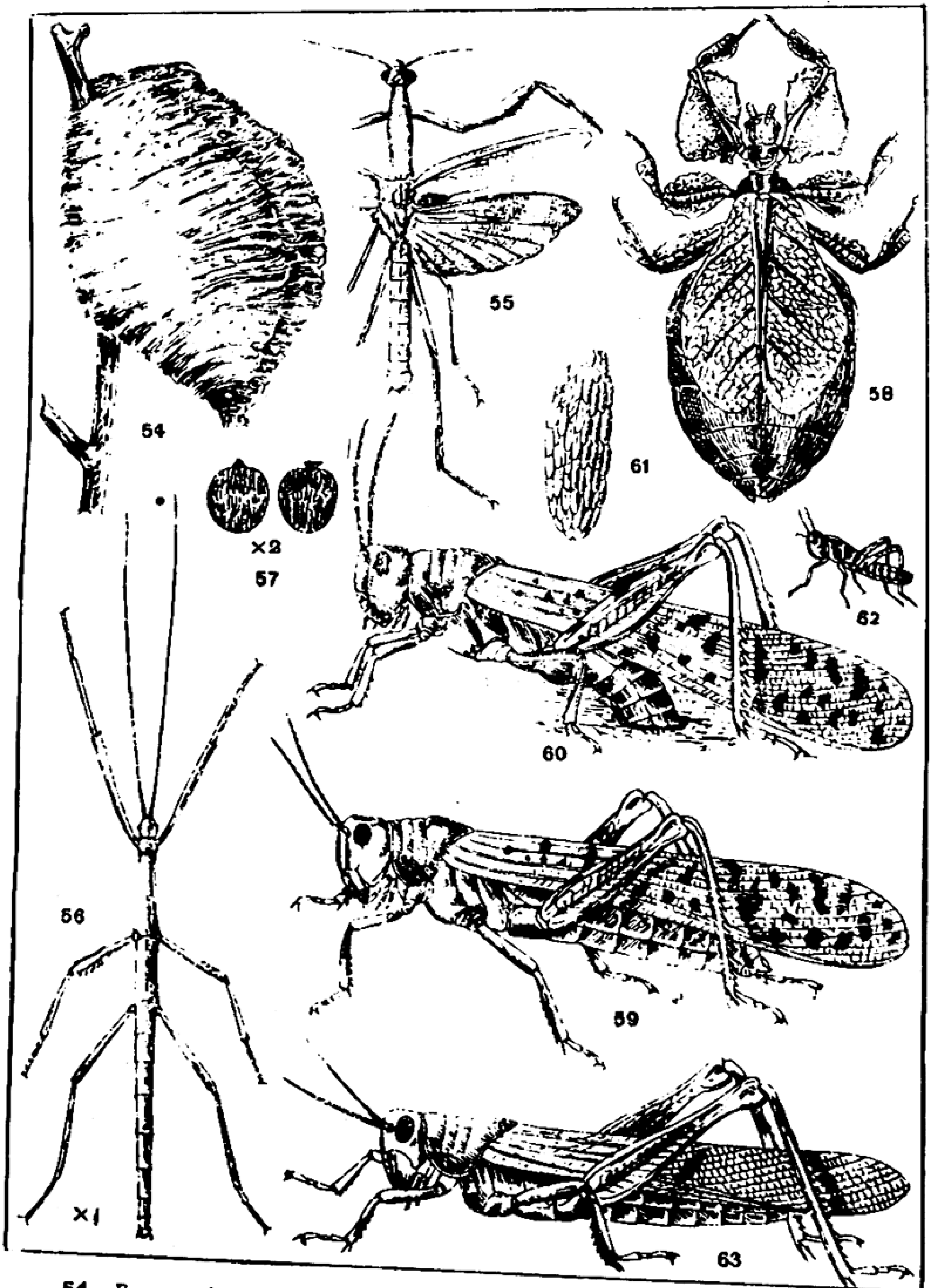
The genus *Phyllium* occurs in the tropical regions of the Old World. A species of *Phyllium*, P. scythe, is the Indian leaf insect (*cf.* fig. 58), whose broad abdomen and upper wings are exactly like a leaf and the legs are flattened out and also resemble portions of leaves. It is an inhabitant of Eastern Bengal and Assam, and the natives of the former locality hold the opinion that the insect is only a leaf, which developed as such originally and then *took to walking*.

Series.—Saltatoria.

Hind legs elongate, formed for leaping, their femora usually thickened.

FAMILY V.—*Acridiidæ* (Locusts).

The hind legs differ from the others by being more elongate and having their femora broader near the base (*cf.* fig. 59). Antennæ short and thick with less than 30 joints. No exserted ovipositor in ♀. Tarsi short with three distinct joints. The auditory organ is placed on the side of the upper part of the first abdominal segment. The large head is joined to the thorax in one piece, the joint being deflexed downwards at a sharp angle. Besides the two compound eyes there are three ocelli present. This family is remarkable owing to the presence of air-sacks in the interior of the insect in connection with the tracheæ, and it is doubtless the possession of these that enables them to undertake the great flights they perform when migrating. The upper wings are pent roof-shaped. The chirping sound of locusts is produced by rubbing together the outer face of the upper wing, one of the veins in



54. Egg-capsule of the praying mantis (*Deiphobe ocellata*) shown in Fig. 55.
56. A Stick insect (*Bacillus artemis*).
57. Eggs of the Stick insect, *Lonchodes virgens*.
58. A Leaf insect (*Phyllium scythe*).
59. *Acridium peregrinum*, N.-W. locust.
60. Female of N.-W. locust egg-laying.
61. Egg mass of N.-W. locust.
62. Young newly hatched locust.
63. *Acridium succinctum*.

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which is prominent and possesses a sharp edge, and the inner face of the hind femur which bears a series of small bead-like prominences placed on the upper of the two lower ridges that run along the side that is nearest to the body.

This family includes the small locusts of the fields and the important migratory locusts of India and other parts of the world. The family contains more species and individuals than any other Orthopterous family and is a most important one, as they all feed on growing plants. It includes what are perhaps two of the most dangerous insects in the world—the great North-West Locust (*Acridium perigrinum*) of India (fig. 59), and the Migratory Locust of North America—insects which at times swarm in millions and clear the country they invade of every green thing; every leaf is stripped from the trees, every blade of grass and crop eaten down, and when the area is utterly brown and bare of green plant life, they move on to a fresh district.

There are many species of Acridiidæ in India, and many at different periods swarm and do damage. We will consider here the life-history of the great Indian Migratory Locust, *Acridium peregrinum*.

Life-history of the North-West or Indian Migratory Locust (*Acridium peregrinum*).

The home of this locust is in the sandy deserts of Rajputana, Sind, and Baluchistan, from which it periodically invades the whole of India. The eggs are laid in holes in the ground which the female digs with her blade-like ovipositor, as shown in fig. 60; as many as 100 eggs are laid in one hole; they are stuck together in a mass with some siccable substance. Fig. 61 shows a mass of these eggs, and fig. 60 a female insect laying them. The eggs hatch out in about a month, but two months or a much longer period may be spent in the egg stage if conditions are not favourable for hatching. The young are little blackish, wingless grass-hoppers (fig. 62), which feed upon green plants of all kinds. At the end of the first five days after hatching the young "hoppers," pack together and march in serried columns into the fields and begin their work of devastation. This stage lasts from one to two months, during which time the insects moult their skins at intervals. Their wings develop during these several moults, and the last shedding of the skin leaves the insect with perfectly developed flight organs. As soon as they are fully mature, the locusts, leaving the areas from which they have already eaten everything green, take wing and fly to fresh districts, which they proceed to devastate in a similar manner. After a week or two spent in these wanderings the insects pair and the females commence egg-laying, choosing for this purpose sandy tracts or the soft soil of the cultivated lands.

When the insect first acquires wings it is salmon pink in colour, but later it changes to yellow and then to a dull purple. The invasions of this insect are periodical, the average number of years that elapses between them being

about eleven, but a longer interval may elapse. The insects may be said to spread down country in a series of waves. The first insects migrating from their sandy home penetrate into the east and south of the Punjab and lay eggs there As soon as they acquire wings the locusts hatching from these eggs proceed further east or south and after a few weeks lay eggs in the new tract invaded. In this way the invasion is carried right down through the country. At the end of the invasion the locusts return to the desert homes of their ancestors, and in this they would appear to be guided by instinct since none of the returning generations have ever seen the desert tracts from which the invasion started. The last great attack occurred between the years 1889-1893, whilst in 1901 the insect spread as far south as Ganjam in Madras and east to the Brahmaputra River. Whilst these great flights are present in a district, green foliage of every description suffers heavily and the bark is peeled off young saplings. Nurseries and young plantations thus suffer severely from this pest, whilst the soft earth of the beds is used by the females for egg-laying.*

In addition to the migratory locust proper, most of the provinces of India have one or two large local locusts, which particularly affect their own part of the country and produce the local swarms which on occasions do so much damage.

* *Treatment.*—When fully developed swarms of locusts are seen near or in the forest, every effort should be made to mark down the places at which they alight. If, after they have left, the surface of the soil is seen to be covered with small holes, like holes made in soft earth by raindrops, eggs have been laid on that area, and these should be got rid of before they hatch out, or the young hoppers should be killed off as soon after hatching as possible and *before* they pack into columns. To do this the eggs may be either dug up and collected or ploughed in deep into the soil so as to destroy them. If it has not been possible to destroy the eggs, the young hoppers should be destroyed by arming coolies with branches, proceeding to the area where the young locusts are hatching out and beating over the whole area. This must be done, however, in the first five days before the hoppers pack into columns. To stop the columns descending upon the forest or cultivation long dry trenches should be dug in the path of the column 1-2 feet deep and of the same width. The locusts should be driven into these by parties of coolies, a line of men standing upon the far edge of the trench and filling it up with earth so as to bury the locusts. As soon as one trench is full the insects should be made to wheel in the direction of another. The earth on the top of the trenches should be well trodden to ensure all the locusts being killed. When, however, the locusts have attained some size the trench is no longer of any use as they can easily hop out of it. It will be found at this period that when disturbed in the open the locusts retire to the nearest cover, such as scrub jungle, and remain there. Heaps of branches or straw or any available material should therefore be made in the path of the locusts who, on being disturbed, proceed to this shelter. These heaps may then be surrounded and set on fire. When swarms of locusts are observed advancing towards valuable forest areas, plantations, or nurseries, all the adjacent villagers should be turned out with drums, kerosine tins, etc., and should be made to advance in a line towards the swarm, beating their instruments. This will result in turning the swarm. Waving clothes in the air should also be tried as well.

Acridium succinctum (fig. 63) is the locust of the Bombay Presidency, and breeds in the Ghâts. It is also to be found in Western Bengal, and probably breeds in the Chota Nagpur hills. In the Nilgiri range of hills in Madras *Acridium æruginosum*, *Acridium melanocorne*, and *Tryxalis nasuta* have their home and are the locusts which at times swarm over the Presidency from that centre. Two species, *Tryxalis nasuta*,* (fig. 64) and *Oxya velox*, have been reported as attacking and injuring young chir (*Pinus longifolia*) and robinia seedlings in the Kangra Valley, Punjab.

Enemies of locusts.—Locusts are preyed upon by two dipterous parasites (both on *A. peregrinum*, one of which attacks the egg, the other the mature insect. In addition a Carabid beetle (*Calosoma orientale*, Hope) and the rosy pastor starling (*Pastor roseus*) cause great havoc amongst the flights.

FAMILY VI.—*Locustidæ* (Grasshoppers).†

These insects are generally known as the long-horned grasshoppers from the fact of their having very long bristle-like antennæ. They are usually grass-green or brown in colour, and their bodies are flattened and more lightly built than the true locusts. The eyes are round, the legs slender, and tarsi four-jointed. Wings are roof-shaped. On the tibiæ of each of the front legs there are two auditory organs, and the males make sounds by rubbing the basal portion of one upper wing, the under-side of which has a transversely ridged edge, over a corresponding portion of the other. The female possesses a long sabre-like exserted ovipositor. Fig. 65 shows a common long-horned Indian grasshopper named *Cleandrus ligatus*. The eggs are laid on the ground or on leaves, stems, etc.

This family is of less importance than the true locusts. It contains the insect known as *Schizodactylus monstruosus*, Brulli, a grasshopper which can be at once recognised owing to the fact that the ends of its wings are curled up in a coil at the end of its body (fig. 66). It is known as "bherwa" in the indigo districts, where at times it commits damage by cutting off indigo, tobacco, and other crop plants with its enormous shear-like jaws. It is also plentiful in Assam and probably in the Madras Presidency. A pest of this kind can commit an incalculable amount of harm in nurseries of young plants.

* See Departmental Notes on Insects which affect Forestry, No. 1, pp. 1-5.

† It will be noted that the *Locustidæ* are not locusts but grasshoppers, the true "locusts" belonging to the *Acridiidæ*: an unfortunate nomenclature which it would be impossible now to change.

FAMILY VII.—*Gryllidæ* (Crickets).

The *Gryllidæ* are closely connected with the *Locustidæ*. The antennæ are long and slender and setaceous; hind legs long and used for jumping purposes. The upper wings have the outside portion bent down on to the side of the body, whilst the inner portion lies horizontally on the dorsal surface as shown in the fully developed insect in Fig. 49. The tarsi are usually three-jointed. The female has a long ovipositor. Wingless forms are numerous. The musical and auditory organs are situated in the same position as in *Locustidæ*. The *Gryllidæ* differ from these latter in the 3-jointed tarsi and position of the upper wings in repose. The body is thick and cylindrical, and the eggs are glued together and laid in holes in the ground. Fig. 67 shows the black field-cricket which is very common round Bombay and other parts.

This family contains some injurious pests of which two more especially harmful will be mentioned.

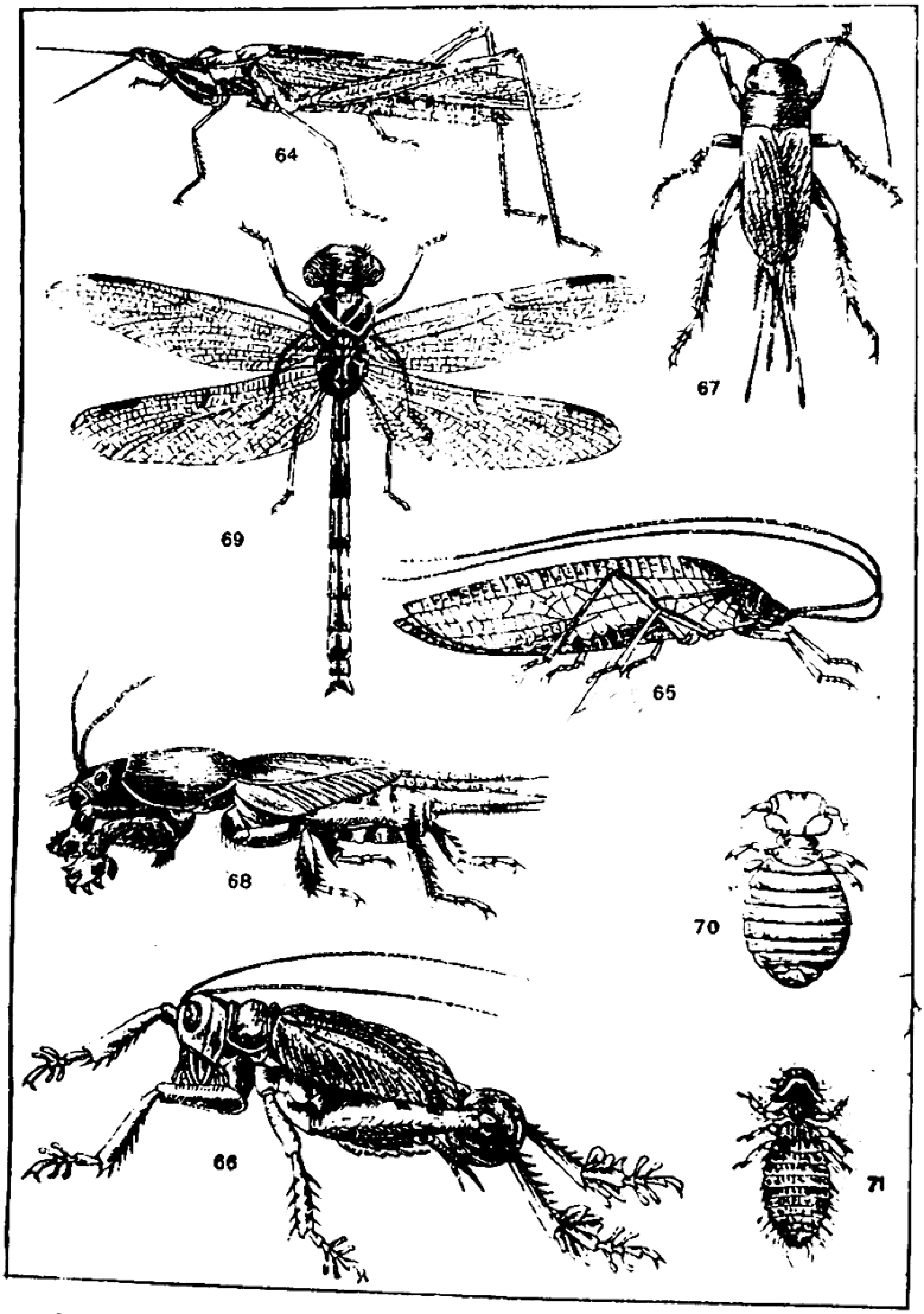
Life-history of the Mole Cricket, *Gryllotalpa vulgaris*.

The Mole Cricket (*Gryllotalpa vulgaris*) is a large insect, which has the front legs thickened for digging purposes, and has the prothorax enormously enlarged, resembling the carapace of a lobster, and there is no ovipositor present. The fore legs have a very short and thick femur and tibia, and the tibia is prolonged into a series of four points and is concave on the outside. The first two joints of the tarsus are prolonged into teeth. The fore wings are very short and oval and the hind wings are rolled up upon themselves like a rolled-up umbrella and extend back in two points (see fig. 68). This insect is dangerous, as it burrows underground in grass lands, gardens, and nurseries, destroying the roots of plants in its operations.

The second injurious species which has proved itself a pest in India is a cricket named *Brachytrupes achatinus*, which has a very wide distribution. This is a large thick-set insect, smoky brown above, yellowish beneath and at the sides; the tibiæ of the hind legs have four stout spines on each. Length 1½-2 inches. Fig. 49 a, b, c, d shows the larvæ and adult of this pest. The life-history of this insect has been partially worked out in the Chittagong Hill Tracts.

Life-history of *Brachytrupes achatinus*.

Larvæ about half grown were found in April voraciously feeding upon young rubber (*Ficus elastica*) seedlings in nursery beds into which the young plants had been transplanted from the pots in which they had been raised from seed. It was not until some 40 per cent. of the seedlings had been killed off that the aggressor was marked down in the holes in which it lives. These are constructed in soft sandy situations, the tunnel starting at an angle to the surface level and running in a



64. *Tryzais nausta.*
65 Long-horned grasshopper (*Cleandrus ligatus*).
66. *Schizo actylus monstruosus.*
67. Black field cricket
68 Common mole cricket.
69. Common dragon-fly.
70. Dog louse.
71. Common fowl louse.

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zig-zag manner down into the soil for some two feet, the diameter of the tunnel being from ½ to ⅓ inch. It is enlarged at the bottom into a small chamber. A burrow may be occupied by one, two, or as many as three young ones. The insect feeds chiefly at night, spending the day in its burrow, into which it drags some of its food plant to consume at leisure. Soft soil is chosen to dig the holes in —and therefore the nursery beds are preferred, but any soft spots in the neighbourhood will be found to contain numbers of the insects. The young larvæ feed till the beginning of the rains, about the middle of June. They then cease until October, and they would appear to rest during the heaviest of the rains, though there is no pupal stage proper. In October the damage in the nursery recommences, and the holes will be found to contain two fully developed insects, male and female, at the bottom of each, the tunnels being now some 2-2½ feet deep and very winding. The insects at this period feed voraciously, and continue to do so for a month. In November they die off, the female probably first laying her eggs in soft patches of soil.*

USEFUL ORTHOPTERA.

The number of Orthoptera known to be of use to the forester is a small one. The *Mantidæ* may be said to be useful to a certain extent in that they destroy insects of all kinds, and in their larval stages in some cases they probably feed largely upon *Aphidæ*. As I have mentioned in my notes under that family, the *Forficulidæ* † are probably of use, since many are undoubtedly predaceous upon larvæ, small snails, etc., which live upon plants.

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* *Remedies.*—All such areas should be carefully and deeply ploughed or hoed up so as to kill off the eggs by exposing them at the surface. When an attack has been discovered in progress, small boys should at once be put on to search each hole and kill the insects in it. This may be done by giving each a pot of water; a little poured down each hole will cause the crickets to come out, when they can be secured. This will be found to be a cheap and effectual method of getting rid of the pest which, if left alone, will do an immense amount of injury. Being a large-bodied insect, some 2½ inches long, it is capable of consuming during its life a considerable amount of green material.

This cricket has been reported as injurious to young tea plants in Bengal and Assam, and in addition to Eastern Bengal has also been reported as attacking teak in the Godhra nursery in the Panch Mahals District, Bombay.

† See Departmental Notes on Insects which affect Forestry, No. 1, p. 6.

CHAPTER V.

ORDER III.—NEUROPTERA.

Imago with a biting mouth; with two pairs of wings, the upper as well as the lower membranous, usually with extensive veins consisting of elongate nervures with cross ones, the whole forming a net-work.

Wingless forms are present. The metamorphosis is incomplete. Fig. 69 shows a common dragon-fly, an example of this Order.

The Neuroptera comprise a comparatively small number of insects, the Order including the termites (white-ants), dragon-flies, stone-flies, May-flies, caddis-flies, lace-wings, ant-lions, etc., and the wingless bird-lice.

With the exception of the termites the insects of this Order are not of great importance. For our purpose we shall consider seven families, six of which we shall do little more than glance at.

FAMILY I.—*Mallophaga* (Bird-Lice).

These are flat, wingless insects furnished with a large head; thorax is usually of two, rarely of one or three, segments; the prothorax always distinct; hind body consists of 8 to 10 segments in addition to the two anterior thoracic segments. The whole of the insects of this family live a parasitic life, creeping about on those parts that are near the skin, *e.g.*, the feathers or hair of birds and mammals. They rarely come near the surface so that they are not detected on a superficial examination. The legs are specially adapted for climbing amongst hairs and feathers, as the last joint of the foot is hook-shaped and can be bent back against the preceding joint; a hair can thus be held fast between the two joints. The eggs are fastened by the mother louse to the hairs, etc., of the host. These insects either suck the blood of the host or eat the fur or feathers. Lice multiply very rapidly on the bodies of human beings and animals when insufficiently cleansed, and consequently they are commoner on sick and ill-nourished individuals than on healthy and well-nourished ones.

Fig. 70 shows the dog louse, *Trichodectus latus*, having one claw to the foot and, 71, the common fowl-louse, *Menopon pallidum*, with two claws to the foot, as is usual in bird-lice (both magnified).

FAMILY II.—*Termitidæ* (Termites, White-ant).

This family of insects live in colonies, similar to the method of life of the ants and bees. The Termitidæ have no characters in common with these latter, however, save this one of living in colonies. The term "white-ant," although the popular name, is misleading as these insects have nothing in common with ordinary ants, to which they are quite dissimilar in structure.

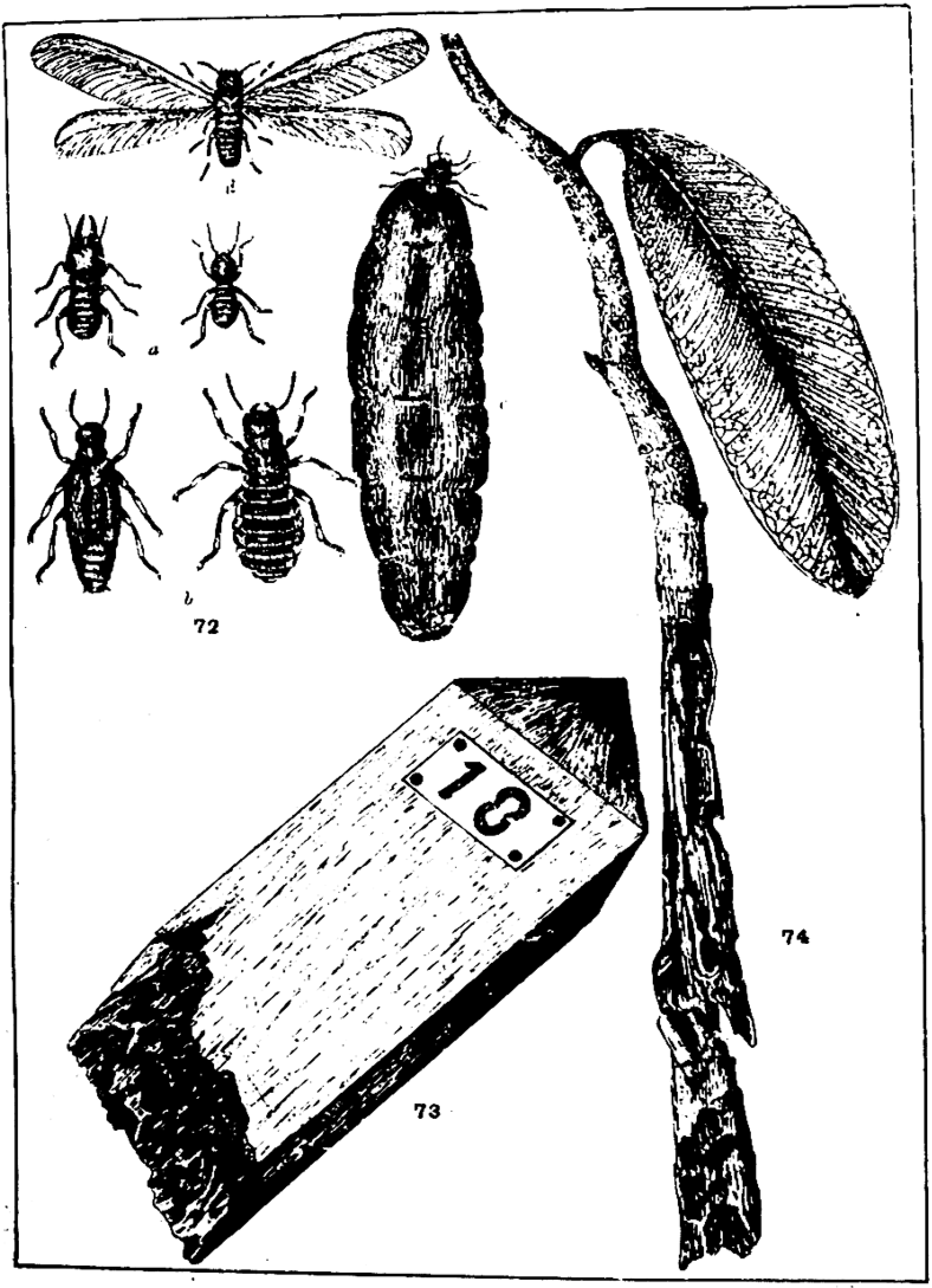
Each species is social, and consists of winged and wingless individuals. Wingless individuals are very numerous and have the head and thirteen body segments distinct; the body is terminated by a pair of short cerci.

The integument is delicate and the chitin plates are never very hard. The head is exserted, frequently of large size and sometimes as large as all of the rest of the body together. Termites may be quite blind or possess simple and compound eyes. Antennæ are moniliform and short, and the legs are like one another. The wings are unlike those of any other insects. The four wings are, in repose, laid flat on the back, so that the upper one only is seen except at the bases; they are membranous and very long so that they extend far beyond the extremity of the body; the hind pair is similar in size and consistency to the front pair; their neuration is very simple, consisting of two longitudinal nervures enclosing a space like a mid-rib between them, smaller nervures taking off from this on either side; the wing thus rather resembles a feather of a bird or a much-veined leaflet. The most remarkable part about them, however, is that near the base of each wing there is a suture or line of weakness, along which the wings can be broken off, the stumps remaining as short, horny flaps on the back. The wings are used for only a single flight and are then shed breaking off at this suture.

The life-history of the Indian Termite, *Termes taprobanes*, is commonly as follows:—

Life-history of the Termite or 'white-ant' (*Termes taprobanes*).

Termites live in communities consisting of an enormous number of individuals. The adult forms found in a community are (1) workers, (2) soldiers, (3) winged males and females, (4) some of these winged forms which have lost their wings (fig. 72, a, b, c, d). In addition, there are the young larvæ. The winged king and queen are only present in the nest for a few days. The individuals which have lost their wings are usually limited to one pair, the king and queen. These latter two may be recognised by



72. The Common "White-ant" or Termite (*Termes taprobanes*). *a*, worker; *b*, soldier; *c*, larva of winged form; *d*, young queen; *e*, female or queen with swollen-up body full of eggs.

73. Boundary post from a forest boundary line in Burma showing the manner in which termites destroy wood.

74. Young rubber plant destroyed by termites. The whole of the bark and portion of the sap-wood has been eaten away.

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the stumps of their cast wings which are to be seen as small appendages on the dorsal surface of the thorax. The continuance of the nest is effected entirely by the king and queen. They are generally incapable of leaving the nest, more especially the queen whose body swells up enormously to many times its original bulk, after fertilisation. Great disorganisation occurs in the colony if anything happens to the royal pair, and in consequence of this certain individuals amongst the larvæ are kept in such a state that by changing the food they can be quickly converted into royalties should it become necessary. It thus becomes obvious that the old theory that it was possible to get rid of a "white-ant" nest by digging out and killing the king and queen is a quite untenable one. When this is done, or when anything happens to these latter, the termites left in the nest simply set about preparing a substitute royal couple.

The soldiers may be distinguished by their very large heads and powerful mandibles. Their work is to guard the colony against enemies. The workers build the nest and look after the young larvæ. For their nests they construct mounds of different shapes and sizes, these being sometimes several feet high with a corresponding depth of ramifying galleries in the earth below the mound. Such mounds are to be seen commonly throughout the warmer parts of India. They are formed of particles of earth worked up into a material which dries as hard as stone. These nests are also made in the interior of trees, the wood being gnawed away and replaced by mud; beams and wooden floors of house, etc., are also made use of in this way. The males and females are produced in enormous numbers, and may often be seen at the commencement of and during the rains issuing in great clouds from the nest, situated either in the big earthen erections or in stumps of trees in the field and forest, or at the base of walls, plinths, etc., of houses. These great flights never fail to attract all the kites, crows, minas, and other insectivorous birds in the neighbourhood, who stuff themselves to repletion with the food thus so easily obtainable. After this nuptial flight and their return to earth, the termites which escape their numerous enemies in the air, tear off their wings and pair, if the pairing has not been gone through in the air. The wingless insects then endeavour to find their way back to the original nest and a few succeed, the greater proportion either being killed off or dying in the attempt. It is to ensure the survival of the few that, in all probability, such enormous numbers of the winged individuals are provided. After return to the nest the body of the queen begins to swell up by a distension of the membrane between the chitinous plates, until it becomes like a sausage 2-3 inches in length, with the minute head and thorax at the top (fig. 72 d). She then lays a number of eggs daily, continuing this performance for a considerable period.

Termites usually never expose themselves to daylight (except the king and queen during the nuptial flight), and consequently the workers make galleries to move about in. When attacking a structure, such as a post, the insects always work on the unexposed sides and in the interior, being very careful to leave all the external portions of the wood intact. It is this habit of theirs which leads to serious accidents, roofs or heavy beams, etc., apparently sound, falling in without

a moment's warning owing to their supports having been entirely undermined unseen by this pest. In the forest large branches of trees may be seen occasionally falling in this way, and examination shows that the apparently sound, though dead, woody branch is but a mass of earth enclosed by the outer shell of rough bark; the whole of the interior has been removed and replaced by mud, every particle of which has been taken up the tree by earthen galleries running up, if the tree is still alive and healthy, on the outside of the bark. Fig. 73 shows the manner in which wood is riddled by these insects.

Termites have also been reported as attacking seedlings of various species of trees, eating off the bark and thus killing the plants. An example of the damage they are capable of committing in this way is shown in Fig. 74 which represents a young rubber plant 5 feet in height from the Lachiwala Nursery, Dehra Dun. The lower part of the stem had been covered with earth and the bark beneath entirely eaten off round two-thirds of the circumference of the stem, the woody interior being also badly riddled. Several of the plants were killed in this attack.*

Termes (*Coptotermes*) *Gestroi* shown in fig. 75, a, b, c has been reported as attacking Para rubber in the Mergui rubber plantations. It attacks the crown of the root of the trees and makes its nest there, often killing the tree. Fig. 76 shows a portion of a crown of a root attacked in this manner.

FAMILY III.—*Psocidæ* (Book-Lice, Death Watches).

Minute insects with slender thread-like antennæ consisting of from 11-25 joints. Prothorax is very small and concealed between the head and the meso-thorax. Four delicate membranous wings are present, the upper pair being the larger.

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* *Prevention.*—In countries where termites are common wooden beams and supports of houses should be constantly and carefully inspected and tested to see that they are not being hollowed out or undermined by the pest. Wooden posts used as supports to wooden bungalows in the forest should be thickly tarred on the ends placed in the ground, and once a year these ends should be exposed by removing the soil and fresh tar laid on, a small pool of tar being formed round the end in contact with the soil. The wooden parts above soil should be inspected, and all mud galleries running up them be brushed off, as the termites will give up the attack once they are exposed to light.

Remedies.—When "white-ants" are troublesome in bungalows or nurseries, careful search should be made for their nests, the earthen galleries, under which the insects are doing the damage, being traced back to the point they emanate from. The nest having been found, all save one or two large openings should be closed and some pieces of carbon bisulphide be pushed into the unclosed openings and these be then closed. The fumes will sink down through the nest and entirely exterminate the colony. Care must be taken to (1) close all the openings, and (2) not to breathe the vapours given off by the carbon bisulphide.

75. The Hevea rubber termite (*Termes Gestroi*). *a*, worker; *b*, soldier.
76. Section of the crown of a root of a Hevea rubber tree showing the galleries made by the termites.

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The small insects found amongst dust and books belong here. Their food is starch or dry animal and vegetable matters, and this is what leads them to attack the bindings, plates, and pages of books. A small psocid, *Psocus ?* sp. (fig. 77), is extremely plentiful on the leaves of the sâl (*Shorea robusta*) tree in the Dun forests during the latter part of February. Small brown patches of rotten tissue appear on the leaves, but whether these are due to the insect or whether the insect is merely feeding upon a fungus which is causing the discolouration has yet to be determined. The insect is a minute yellow one, both larvæ without wings and winged individuals being present. The family has at present only been reported as feeding upon rusts, fungi, vegetable refuse, etc.

FAMILY IV.—*Odonata* (*Libellulidæ*) (Dragon-flies).

Elongate insects with a very mobile head and large eyes, strong mandibles, a broad lip and small inconspicuous antennæ ending in a bristle; four elongate wings equal in size and similar in texture. All the legs are placed more anteriorly than the wings. The abdomen is elongate, being very much narrower than the thorax.

The attachment of the head to the thorax is such that it is possible for the insect to move it round with great ease. The eyes are often enormous and occupy the greater part of the head. There are three ocelli. The earlier stages of the life are spent in water, the larvæ breathing by means of tracheal gills. Metamorphosis is

When nursery or roadside trees are subject to attack they should be painted for several feet up from the base with the mixture known as 'Gondal Fluid.' This fluid is prepared as follows:—1 part *dekamali* gum (this is the resin of *Gardenia gummifera*) 2 parts of asafœtida (*hing*); 2 parts bazar aloes (*gugul*); 2 parts castor oil; pound these materials together and thoroughly mix; when the mixture is decomposed into a thickened compound add water till it is the consistency of paint; some colouring matter, such as red or yellow ochre, should be added in order to render the material visible when painted on the trees. Paint on the trees in a continuous band of 2-3 feet high starting from the soil level and taking care to paint all interstices of the bark. All earthen galleries must be removed before painting the stem. This mixture has been used with good effect and is cheap.

In houses tar well all stone, earthen, or wooden floors, both round the edges and up the walls for a few inches and in the centre, before laying down mats, carpets, etc. This should be renewed at intervals, depending upon the abundance of the pest in the neighbourhood.

incomplete, but there is a great change in the appearance of the insect at the last moult.

The family is carnivorous and the mature insect catches its prey on the wing. The eggs are deposited either in water or on the stem of some aquatic plant. The young on hatching have no wings and are quite unlike the mature insect. The wings begin to appear at the fourth moult. Just before the last moult the larva climbs up the stem of an aquatic plant and fixes itself at the point where the stem leaves the water. It then moults, the skin splitting down anteriorly, and the winged insect crawls out and up the stem where it remains for a time to allow the wings to harden. The family is unimportant economically. Fig. 69 shows a large dragon-fly, *Tetinus rapax*, common in Calcutta, and Fig. 78 a graceful emerald green-bodied one, *Neurobosis chinensis*, the lower wings of which are coloured emerald green, shading off into brown.

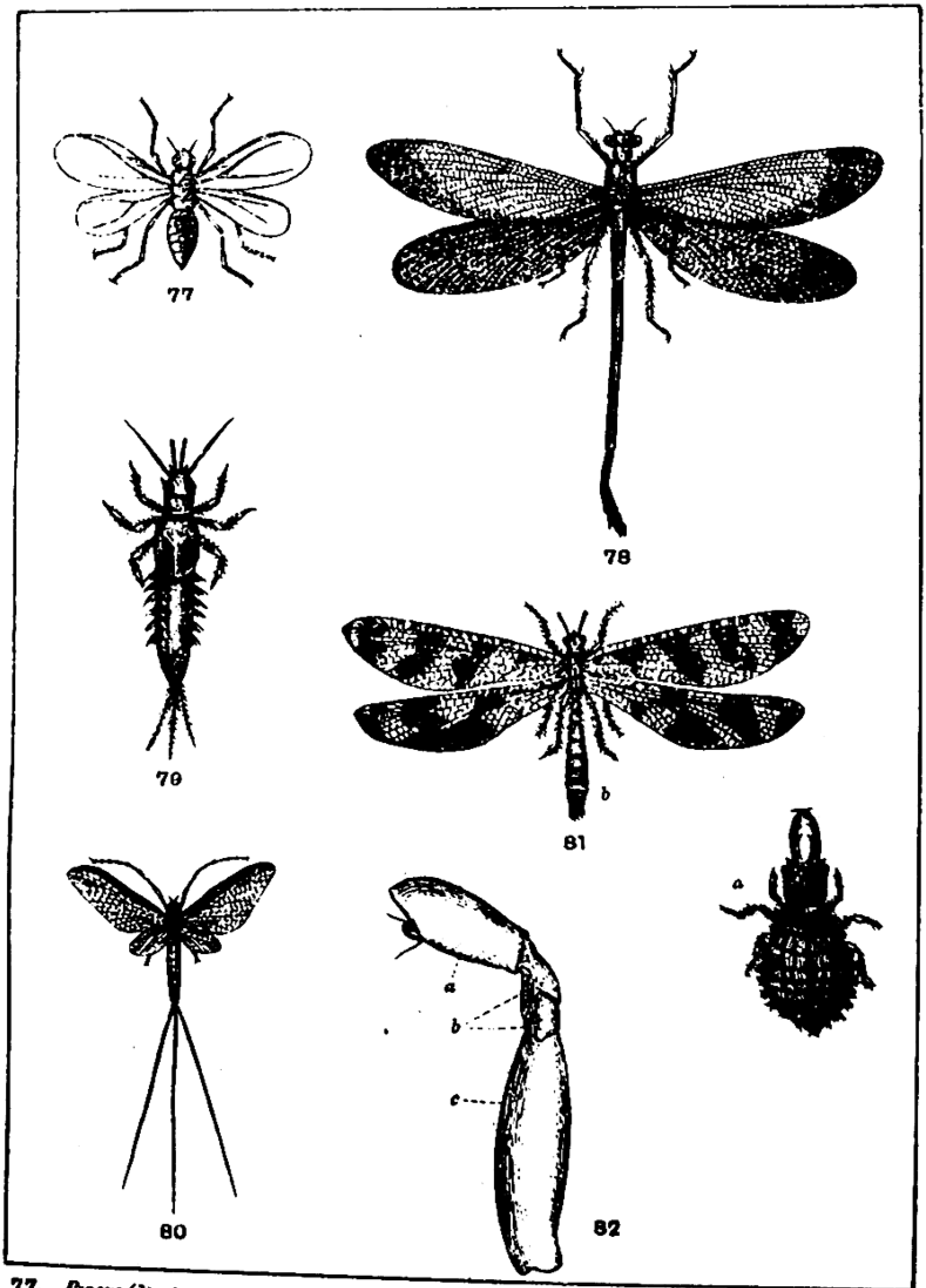
FAMILY V.—*Ephemeridæ* (May-flies).

Delicate insects with short antennæ; four membranous wings, the hinder pair smaller than the others; the body terminated by two or three very elongate slender tails. The earlier stages are passed in water, the larva differing greatly from the adult. Fig. 79 shows an enlarged aquatic larva of this family, and 80 a May-fly (*Ephemera remensa*). The May-flies are not of economic importance.

FAMILY VI.—*Hemerobiidæ* (Ant-lions, Lace-winged flies, etc.).

Insects with a vertical head; maxillæ free, with five-jointed palpi; the labial palpi three-jointed. Wings equal in size and highly net-veined. Tarsus five-jointed. The metamorphosis here is exceptional, it being almost complete. The larvæ have mandibles and maxillæ forming spear-like organs, which are also used for sucking. The insects have in fact a suctorial mouth in the earlier stages of their life-history and a biting one in the adult. This is unusual and the reverse of what occurs in the *Lepidoptera* and other big Orders. The pupa has the general form of the imago, and is enclosed in a cocoon. These insects live on land in all the stages of their existence.

In the *Myrmeleonides* (ant-lions the antennæ are short, clubbed and the apical spaces of the long wings contain regular oblong cellules



77. *Psocus* (?) *sp.*
78. The green-winged dragon-fly (*Neurobasis chinensis*).
79. The common May-fly (*Ephemera remensa*), larva.
80. Common May-fly.
81. Common Indian Ant-lion *Palpares sp.* *a*, larva ; *b*, ant-lion fly.
82. Divided trochanter of an Ichneumon. *a*, coxa ; *b*, the two divisions of the trochanter ; *c*, femur (after Sharp).

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in them. The larvæ are small, dull coloured, with very large shear-like mandibles and a flat oval body. Fig. 81 a, shows the larvæ and fig. 81 b, the imago of the ant-lion common round Dehra. These insects are interesting owing to the fact that the remarkable habits of the larvæ have been known to naturalists for over two centuries. The larvæ are predaceous and secure their prey by means of inverted cone-shaped pit-falls, which they excavate in sandy places and at the bottom of which they bury themselves, leaving only their elongate jaws projecting out of the sand at the bottom of the pit. The latter being constructed in dry loose sand, an insect running along the ground and reaching the edge slips on the moving sand and falls to the bottom of the pit, to be impaled on the sharp mandibles of the larva, who then sucks out its juices. Even should the insect not be impaled upon the mandibles, the ant-lion larva will secure it before it has managed to escape up the shelving slipping sides of the pit. These insects are common in many parts of India, more especially in dry sandy river-beds, etc.

The *Chrysopides* (lace-wing flies) are fragile insects with elongate bristle-like antennæ. They have metallic red-coloured eyes, by which they can be recognised. They are of no importance to the forester so far as present observation has shown.

FAMILY VII.—*Phryganeidæ* (Caddis-flies).

The wings are more or less clothed with hair, the hind ones being larger than the front, and are held in a roof-shaped manner over the body when at rest. Antennæ are thread-like, mandibles are absent. The metamorphosis is nearly complete. The larvæ are caterpillar-like, usually inhabiting cases of their own construction. The pupa resembles the perfect insect.

These insects have the appearance of small black moths (*Lepidoptera*) and are to be found in the neighbourhood of water, in which the larval stage is passed.

USEFUL NEUROPTERA.

The Order cannot be said to contain many insects of use to the forester. The dragon-fly, in its adult condition, and the ant-lion larva

are both carnivorous, preying upon insects, and both probably do a certain amount of good by catching and feeding upon noxious insect pests. It is not improbable, however, that they also in this way kill off useful insects. The dragon-fly catches its prey entirely upon the wing.

CHAPTER VI.

ORDER IV.—HYMENOPTERA.

Wings four, membranous, without scales, usually transparent, never very large, the posterior pair smaller than the anterior ; the cells formed by the nervures irregular in size and form, and never very numerous (less than twenty on the front, than fifteen on the hind wing). Mandibles conspicuous, even when the other parts of the mouth form a proboscis or sucking tube. The females are furnished at the extremity of the body with either saw, sting, or ovipositor; these parts may be either withdrawn into the body or be permanently protruded. Metamorphosis is complete. In the pupal stage the parts of the perfect insect are seen nearly free, each covered in a very delicate skin.

The Order *Hymenoptera* includes the wood-wasps, saw-flies, gall flies, chalcid flies, ichneumon flies, and also the families of bees, wasps, and ants. It is a very large Order of which a very large number of species remain to be discovered and described, and this is especially the case in India.

The head is short and broad, and deeply constricted off from the prothorax, never sunk into it; sometimes it is situated on the stalk-like process of the prothorax. The mandibles are powerful biting organs. When the proboscis is present, the "tongue," which is formed by the joined ligulæ, is elongate and gutter-like ventrally and is surrounded by a tube formed of the long flattened labial palps and blades of the first maxillæ (*see* fig. 104) ;,by means of the tongue and its sheath sweet liquids are sucked up into the mouth. The prothorax is but feebly developed, the dorsal is separated from the ventral portion, and is firmly fused on to the meso-thorax, whilst the latter (with the first pair of legs) is movable. Meso-thorax and metathorax are usually immovably united, but in the saw-flies and wood-wasps they are freely movable. The legs are characterised by the size of the coxæ; the trochanter is often divided into two joints (*cf.* fig. 82) (in the Tenthredinidæ, Uroceridæ, Cynipidæ, and Ichneumonidæ) ; the tarsus is five-jointed, and the first joint is longer than the following. The upper and lower wings are connected by a tow of small hooks on

the anterior edge of the hind wing, which fasten into the curved hinder edge of the front one; thus during flight the two wings on one side act as one piece (*see* fig. 83 A-C). At the base of the front wing there is a projecting scale which covers the base of the hind wing. In all the Hymenoptera the first abdominal segment is immovably united with the metathorax, and in the majority (*i.e.*, in all but the families Tenthredinidæ and Uroceridæ) there is a deep constriction between this and the following abdominal segments; the abdomen is thus said to be *stalked* (*cf.* figs. 94b and 112, but it must not be forgotten that the constriction occurs not between the last segment of the thorax and the first segment of the abdomen, but in the abdomen itself; the segments following the constriction are usually narrower than the first. The eggs when being laid pass through the hollow stabbing or boring apparatus at the end of the body of the female (*cf.* fig. 96); in many cases a prick or cut is made in an animal or plant for the reception of the egg. This apparatus may also act as a sting. The larvæ are usually whitish blind grubs (*cf.* figs. 84a, 85a); only in the Tenthredinidæ and Uroceridæ do they resemble the caterpillars of the Lepidoptera (*cf.* fig. 87 and figs. 242a, 244). The larvæ generally form *cocoons* to pupate in (fig. 88 b).

Both parthenogenesis and alternation of generations occur in this Order, both frequently occurring in the Cynipidæ.

From a forester's point of view the Order may be sharply separated off into three distinct divisions :—

(*a*) Those insects doing direct injury to the forest, *e.g.*, Sirex, etc.

(*b*) Those insects of direct benefit to man owing to their parasitic habits, *e.g.*, Ichneumonidæ, Chalcidæ, etc.

(*c*) Those insects of direct benefit to man owing to their economic importance as, *e.g.*, Bees—

(i) owing to the fact that they furnish honey and wax;

(ii) play an important part in the economy of nature by fertilising flowers and thus ensuring the fructification of the plant.

The Order consists of two very distinct sub-orders dependent upon the manner in which the abdomen is joined on to the thorax, *viz.*—

(1) *Hymenoptera Sessiliventres.*—Insects with the abdomen

broad at the base (fig. 85 c), its first segment not completely joined to the metathorax.

(2) *Hymenoptera Petiolata.*—The abdomen connected with what appears to be the thorax by a slender joint forming a marked constriction between the apparent thorax and abdomen (*cf.* figs. 94 b and 112), the posterior part of the apparent thorax consisting of the first abdominal segment.

I.—HYMENOPTERA SESSILIVENTRES.

The abdomen is not stalked, but is nearly continuous in outline with the thorax. Trochanters divided into two portions. The saws or boring apparatus of ♀ are concealed or only just visible. Larva has three pairs of thoracic legs and often numerous abdominal legs which have no hooks. Food is vegetable, some feed in galls on plants, some on twigs, others on the hard wood of trees and shrubs. The majority, however, live on the leaves of plants. Those which feed on wood resemble Coleopterous larvæ in appearance, and those which live on leaves resemble Lepidopterous leaf-feeding larvæ.

We shall consider here three families.

FAMILY I.—*Cephidæ* (Stem Saw-flies).

Slender insects with a weak integument and slender antennæ. The female bears a saw at the end of her body. Larvæ live on the stems of plants or on the tender shoots of trees and shrubs.

Little is known about these insects in India. One, however, *Cephus ?* sp., has been found living at the bases of the young spring needles of the deodar. The needles develop on the branches in small rosettes (fig. 84c) and if these be examined when attacked by this small insect they will be seen to have swollen up at their bases in such a manner that the needles coalesce at the bottom. A closer examination shows that the swelling is convex on the outside and concave on the inner one, and in this small concave elliptical depression (84d) a tiny orange grub will be found (fig. 84 a). The irritation set up by its feeding operations causes the swelling at the base of the needle. From four to six weeks are spent in this stage of its existence; the pupal stage is a short one, and about the middle of June and beginning of July the tiny little brilliant metallic blue flies (84 b), $\frac{1}{16}$th inch in length, issue. The attacked rosettes turn yellow and dry up, a certain amount of defoliation being accomplished in this way.

Life-history of *Cephus ?* sp.

FAMILY II.—*Siricidæ or Uroceridæ* (Wood-wasps).

Large insects of bright conspicuous colours, the female being provided at the extremity of the body with an elongate, cylindrical boring instrument. Antennæ filiform and elongate; the prothorax is joined to the meso-thorax, being perpendicular in front; the abdomen has 8 dorsal plates, and the front tibia has a spur; the anal lobe of the posterior wing is large. The larvæ live in wood, in which they gnaw long winding passages; they are blind, whitish grubs with three pairs of short thoracic legs, but have no abdominal legs, only slight protuberances being present. The pupa is naked, *i.e.*, it is not enclosed in any cocoon. Fig. 85 a-d shows the larva, pupa, and imago (♂, ♀) of the large Himalayan wood-wasp *Sirex imperialis.*

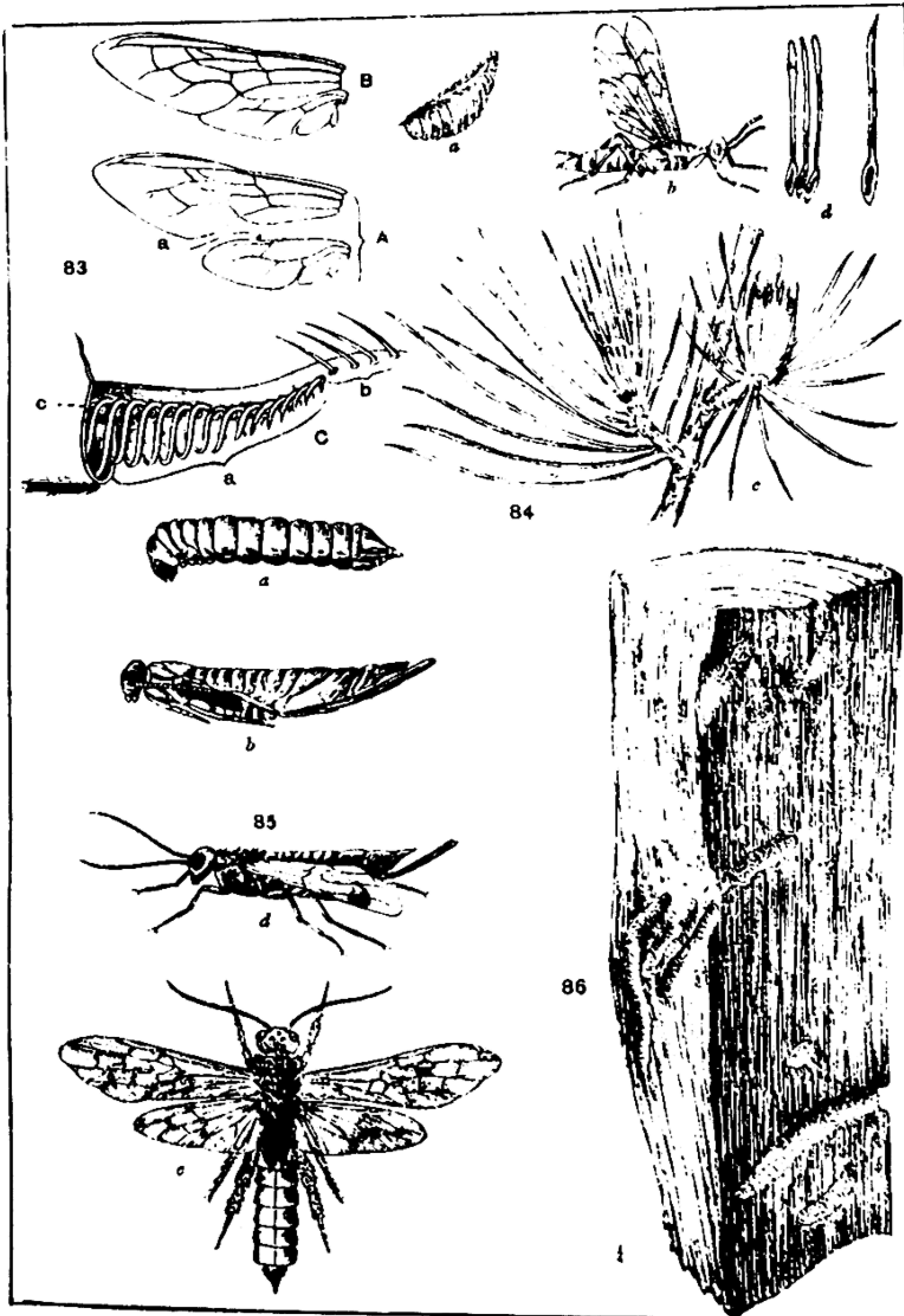
Until recently the habits of the Indian Forest *Siricidæ* were unknown. The life-history of *Sirex imperialis*, the Himalayan or spruce wood-wasp, a magnificent insect not unlike the well-known and oft-quoted *Sirex gigas* of Europe, has been partially worked out and will be described shortly here.*

Life-history of *Sirex imperialis.*

Sirex imperialis is a large handsome insect, the general colouring of the male being a deep metallic blue-green, and rich chestnut, the wings having a coppery sheen on them. The female is a deep metallic green on its upper surface (figs. 85, c, d). The grub is stout, thick, canary yellow in colour, and about 1¼ inches in length. The pupa is unenclosed in any cocoon, being pale yellow in colour (figs. 84, a, b).

The female lays her eggs in the wood of dead spruce, *Picea Morinda*, Link, in the North-West Himalayas (6,500 to 8,000 feet), drilling holes into the tree by means of the augur and drilling apparatus at the end of her body. The larvæ on hatching out bore winding galleries in the wood, these galleries having no apparent definite direction. The grubs evidently spend more than a year thus tunnelling in wood, larvæ of various sizes being obtainable at any time. The larval tunnels, which are several inches in length, are tightly packed with the wood sawdust passed through the body of the boring grubs. When full fed the larvæ change to pupæ at the end of their tunnels with no special preparation, and the pupa is thus found lying naked at the end of the boring, occupying the only free space unblocked with wood refuse in it. The larvæ pupate about June, and fully developed imagoes emerge in July. When ready to leave the tree the mature sirex bores its way out by a circular boring, an eighth of an inch in diameter, drilled in the wood by means of its powerful mandibles, and it invariably chooses the

* For a fuller account see 'Departmental Notes on Insects that affect Forestry,' Vol. I, p. 151, and plate VIII.



P.-M. & Litho. Dept., T. College, Roorkee.

Photo.-Zinco., November, 1906.—No 3947 5.

83. Wings of a Carpenter Bee. **A.** The pair of wings separated; *a*. position of the hooks. **B.** The same wings when united by the hooks. **C.** Portions of the two wings; *a*, the hooks; *b*, marginal hairs; *c*, portion of edge of front wing, the other part is broken away to show the hooks (after Sharp).

84. *Cephus sp.* *a*, larva; *b*, fly; *c*, deodar branch showing effects of attacks; *d*, attacked needles with swollen bases.

85. *Sirex imperialis.* *a*, larva; *b*, pupa; *c*, *d*, ♂ and ♀ flies

86 Spruce wood showing larval tunnels of *Sirex imperialis.*

[to face page 56.

shortest route to the outside, the gallery having, however, usually a slight upward direction.* Fig. 86 shows a block of spruce wood exhibiting the tunnels made by the grubs, most of the borings being blocked with the compressed wood excreta.

This insect is capable of doing the most serious injury to timber, as the winding galleries of the larva and the exit holes of the mature insect riddle the wood and make it useless for anything save firewood. Further study of the habits of this insect may show that it attacks other coniferous trees.

Other, as yet undescribed, species of this genus have also been recently found boring into spruce in a manner similar to the sirex. They are not unlike the latter, but are smaller and blackish in colour.

The larva of a species of sirex has been found boring into sandal wood in the Coimbatore Hills in Madras, but little is known about its life-history at present.

FAMILY III.—*Tenthredinidæ* (Saw-flies).

The perfect insects have a superficial resemblance to a large blue bottle fly, but can be distinguished by having four wings instead of two; the prothorax is small and fits closely to the meso-thorax; there are no spurs, but two spines on the front tibiæ of the legs. The larvæ are very like caterpillars, having three pairs of thoracic legs and six to eight pairs of abdominal ones; in this they differ from Lepidopterous caterpillars, which never have more than five pairs of abdominal legs. Saw-fly larvæ feed exposed on the leaves of plants in the same way as caterpillars, or they may live in galls, etc.

This is an important family, but little is known about its members in India, and practically nothing about their habits.

Recently, three species, as yet unnamed, have been found feeding upon coniferous trees in the North-West Himalayan forests. Of these one infests the deodar, a second the spruce, and the third the silver fir. Observations made on their habits show that they all feed upon the spring crop of needles of these trees, pupating some time in July. The larvæ are bright green in colour and about an inch or a little over in length. When feeding they take up a very characteristic position, which greatly facilitates their recognition, for they coil the lower end of the body round the leaf upon which they are feeding (fig. 87). When full grown they change to pupæ within small light brown elliptical cocoons, the covering of which is of parchment-like consistency, which they attach to a needle. In the case of the silver fir saw-fly the larva pupates at the beginning of July, the mature fly issuing about the middle of the month.

Almost every year a plague of green saw-fly larvæ make their appearance in the autumn (September-October) on rose bushes in the Dehra gardens and

* *Vide* a note on the habits of the larvæ and adults of *Sirex* and *Thalessa* by the author in *Nature* of August 21st, 1902.

strip many bushes of their leaves. The caterpillars spend two weeks in the larval stage and 4-6 days as pupæ. The pupa is enclosed in a cocoon which is attached to a leaf or small branch of the plant. The flies on issuing apparently pair at once and lay eggs. Fig. 88 a--d show the larva feeding on a leaf, cocoon, pupa and fly.

II.—HYMENOPTERA PETIOLATA.

The hind body is connected with the thorax by means of a deep constriction, so that there appears to be a stalk between it and the thorax. This stalk may be long or short, but is always present. This sub-order is divided into three series—

1. PARASITICA or TEREBRANTIA, including the families *Cynipidæ, Chalcidæ, Ichneumonidæ*, and *Braconidæ.*
2. TUBULIFERA—comprising the *Chrysididæ.*
3. ACULEATA—including the families *Apidæ, Diploptera, Fossoria*, and *Formicidæ.*

SERIES I.—*Parasitica* or *Terebrantia.*

The trochanters (the second joint of the leg) are of two pieces (fig. 82), and the female is furnished with an ovipositor at the extremity of her body.

FAMILY IV.—*Cynipidæ* (Gall-flies).

Small, frequently minute insects, usually black or pitchy in colour; the abdomen is short and compressed, with an ovipositor arising from the ventral surface. The wings have only a few cells in them and have no stigma (a black patch) on the anterior margins of the upper wings. The antennæ are straight, simple, and are composed of a few (12-15) joints (fig. 89). The larvæ are small curved whitish grubs and live in galls on plants or parasitically in the bodies of other insects, either singly or several together. The female bores into the living portions of plants (stems, leaves, buds) by means of the spine at the end of the abdomen, and deposits an egg in the hole thus made. The larvæ on hatching out feed upon the plant tissues and the irritation set up gives rise to swellings to which the name of 'gall' is given.

The different forms of gall thus arising are characteristic of different species of insect. In many species a regular alternation of

a parthenogenetic with a true sexual generation exists, the two generations being dissimilar and causing galls of very different appearance.

Little is known about the life-histories of gall-flies in India, although the family probably contains numerous species which damage the seeds and fruits of trees. The life-history of a species known as *Callirhytis semicarpfolia* has been partially worked out.

FAMILY V.—*Chalcididæ* (Chalcid Flies).

These differ from the last family in having elbowed antennæ consisting of from seven to thirteen joints. The wings are without a system of cells in them; there is a single well-marked nervure running from the base near the upper margin, one short vein being given off from it. The insects are frequently of brilliant colour, and remarkable form. This family is one of considerable importance owing to the habits of its members. The larvæ are mostly parasitic; some live in galls feeding upon the grubs which give rise to the galls; others attack caterpillars, others pupæ only; some parasitise bees or Coccidæ and Aphidæ and some deposit their eggs in the egg-cases of Blattidæ. A few are known to prey upon useful parasitic Tachnid flies.

Several species of this family have been reared from forest defoliating caterpillars. *Chalcis euplæa* (fig. 90) has been bred from some caterpillars of the families *Lymantria* and *Dasychira* which at times completely defoliate the sâl in the Bengal Duars and Assam. Occasionally these caterpillars increase in incredible numbers and eat off every leaf from the trees. This leads, after the insect has passed through 2-3 generations, to a similar large increase of the chalcid pest, owing to the exceptional abundance of its food-supply, and the caterpillars are finally decimated and the insect brought down to its ordinary numbers in the forest again. The scale insects (*Coccidæ*) contain serious pests both to the planter and the forester, and observation has shown that many of these scale pests are parasitised by chalcid flies, *e.g.*, *Aphelinus theæ* is parasitic on the tea scale-bug (*Chionaspis theæ*); *Encyrtus nietneri*, *Scutellista cyanea*, *Marietta leopardina*, etc., are parasitic on the brown bug (*Lecanium coffeæ*) of coffee, and so on. Another little chalcid fly (fig. 91) is parasitic on the well-known cheroot-weevil (*Lasioderma testaceum*), the fly laying its eggs in or close to the beetle grub in the cheroot. Undetermined species of chalcids have been obtained from the larvæ of bark-boring Scolytidæ (Scolytus, Polygraphus, and Pityogenes, which infest deodar and blue pine). An instance of an injurious species of this family is *Perilampus* sp. (fig. 92) which is parasitic on one or both of the Tachnid flies, *Trycolyga bombycis* and *Masicera dasychiræ*, which are parasitic upon the caterpillars of a bad sâl defoliating species of *Dasychira* (probably *D. horsfildi*).

FAMILY VI.—*Ichneumonidæ* (Ichneumon Flies).

The ichneumons are insects with a long slender body and many-jointed antennæ. The wings have a well-developed series of nervures and cells in them; the space on the front wing separating the second posterior cell from the cubital cells is divided into two cells by a transverse veinlet (fig. 98 a). The female has usually a long protruding ovipositor.

These insects are parasitic in their larval stages, their hosts being very often caterpillars. The egg is deposited by the mother in the body of the caterpillar. The larva on hatching out is a little white, legless grub, which feeds upon the fatty tissues of his host, the latter eventually dying of exhaustion, though it may have sufficient strength to turn into a pupa first. When full fed the ichneumon grub spins a cocoon, which may be attached to the body of the dead caterpillar or may be free inside or outside of the pupal case of the host. It often happens that two or three eggs or a much larger number are laid upon the caterpillar by the ichneumon fly and then a number of cocoons are obtained from the dead caterpillar or from the pupa into which it has changed. The members of this family thus perform a very important service in the forest by parasitising and keeping down defoliating larvæ and wood-boring pests, and in fact insect pests of all kinds. At the same time they are also injurious to some extent owing to the fact that some species lay their eggs in and kill off useful predaceous and parasitic insects.

The members of the genera *Rhyssa* and *Thalessa* are among the most remarkable of the ichneumon flies. These insects have ovipositors of as much as three to four inches in length, and are parasitic upon species of the family *Siricidæ* which, as above described, live in solid wood. The life-history of a species of *Rhyssa* * parasitic upon *Sirex imperialis*, already described as infesting spruce in the North-Western Himalayas, has been partially worked out.

Life-history of Rhyssa sp.

The mature insect appears on the wing about the beginning of June. The female is a fairly large handsome fly, black in colour with yellow spots upon the thorax and a pink spot on either side of each segment of the body. The insect is one inch in length with an ovipositor of one and-a-half inches (fig. 93).

* *Vide* a note on 'The habits of the larvæ and adults of *Sirex* and *Thalessa*' by the author in *Nature* of August 21st, 1902.

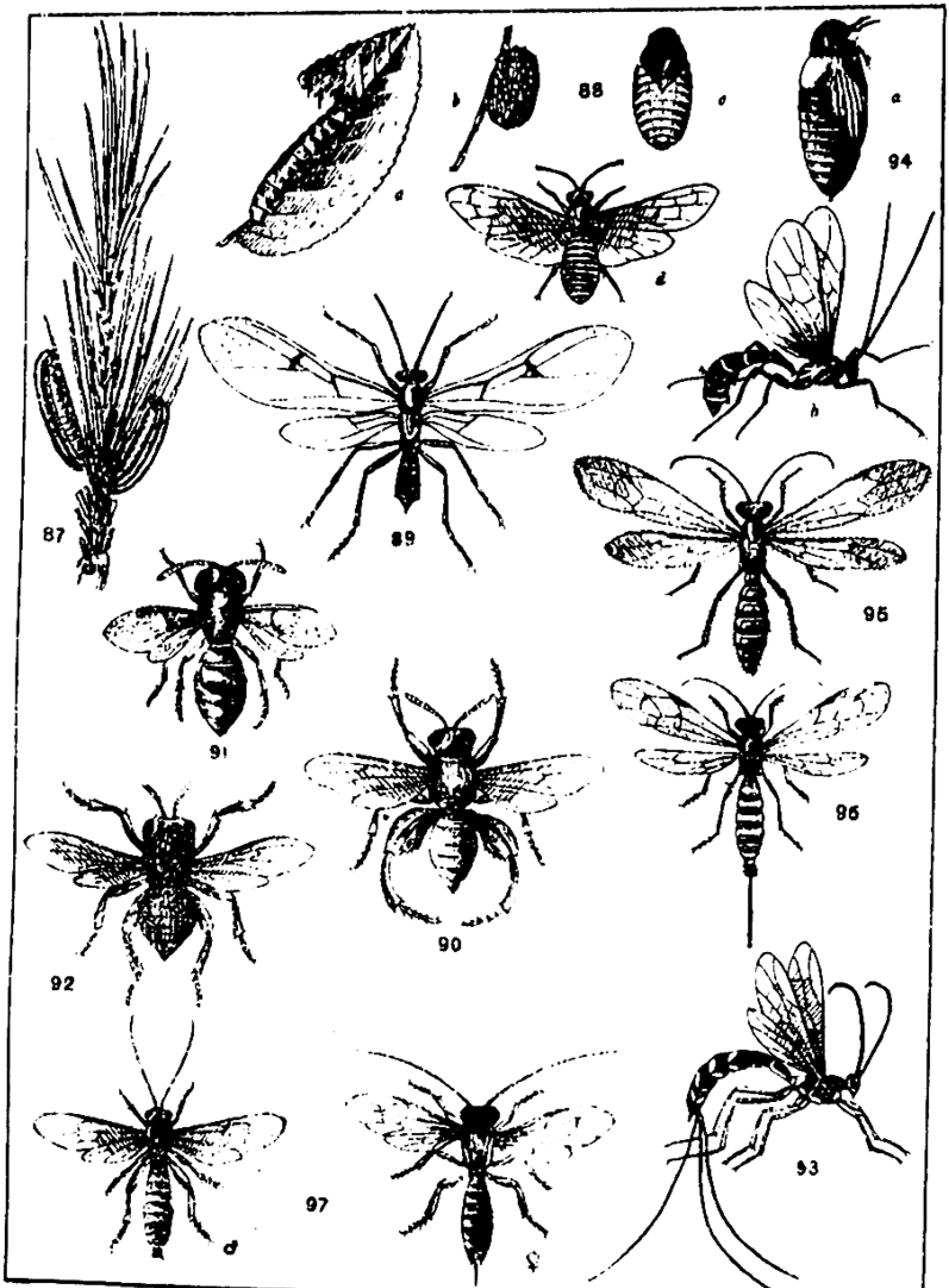


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Photo.-Zinco., November, 1906.—No. 2347-2.

87. Saw-fly larvæ feeding upon Deodar needles
88. Dehra rose leaf saw-fly. *a*, larva on leaf; *b*, cocoon, *c*, pupa; *d*, fly.
89. A gall-fly.
90. *Chalcis euplœa.*
91. Chalcid parasite of cheroot weevil.
92. *Perilampus sp.*
93. *Rhyssa sp.*
94. *Ophion aureolatus.* *a*, pupa with fly issuing; *b*, fly.
95. *Glypta sp.*
96. *Pimpla sp.*
97. *Pimpla punctator* ♂, ♀.

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The larval and pupal stages of the ichneumon have not yet been found. The egg is probably laid by the female ichneumon near or on the young larva of the sirex and the Rhyssa grub feeds upon the sirex larva as an external parasite. When the sirex larva is full grown the ichneumon grub pupates at the end of the tunnel bored by the sirex larva, the latter dying. When mature the ichneumon imago bores its way out of the tree by the shortest route. There can be little doubt that this parasite is of the greatest service in keeping down the numbers of the sirex. It appears to itself suffer when the wood-wasp larva has gone very deep into the wood, as the ichneumon fly has then apparently not sufficient strength to bore its way out of the tree, and dies in the wood after having gone a certain distance. The flies can often be found in this position in dead spruce trees.

An ichneumon fly of some importance is *Ophion aureolatus* (fig. 94) which is parasitic upon the horse chestnut defoliator *Acronycta anædina* in the North-West Himalayas. The caterpillars appear in June and the fly apparently lays its eggs in or near them about this time. The caterpillar is full grown and pupates in August and then dies, the ichneumon grub, by then full grown, pupating inside the cocoon and chrysalis of the caterpillar (fig. 94, a). The winter is passed in this stage, the fly (fig. 94, b) issuing the following year. Species of *Glypta* and *Pimpla* (figs. 95 and 96) are parasitic upon the teak defoliator *Hyblæa puera*, flies having been bred out in the first week of September from caterpillars taken in the latter part of August in the Nilambar Teak Plantations in Malabar. Another ichneumon parasite of some importance is *Pimpla punctator* (fig. 97) whose grub is parasitic upon the silkworm *Antheræa roylei* and is also parasitic upon several species of *Saturniidæ*, a family of moths whose caterpillars are serious defoliators in the forest. Other ichneumons are parasitic upon various species of bark-boring and wood-feeding beetles of the families *Buprestidæ*, *Bostrichidæ*, *Cerambycidæ*, *Scolytidæ*, etc.*

FAMILY VII.—*Braconidæ* (Bracon Flies).

These insects are very similar to the ichneumons. The antennæ consist of many (nearly always more than 15) joints, and the wings have a moderate number of cells in them. They can be distinguished from the ichneumons by the fact that the hind body has a much less degree of mobility of its segments and the upper wings differ, the series of cells running *across* the wing being only three in the Ichneumonides, whereas they are four in the Braconides, and a centre cell behind two and three is divided transversely into two in the former, but is undivided in the latter (*cf.* fig. 98 a, b). If these distinguishing characters are remembered the two families can always be distinguished from one another.

* For a fuller account see 'Departmental Notes on Insects which affect Forestry,' Vol. I, p. 155, and plate VII, Fig. 2.

The habits of this family are similar to the last, it being believed that they are nearly all parasites. Usually they attack larvæ, but they are bred in great numbers from pupæ and occasionally from imagoes of other insects. Little is known about the Indian representatives of the family. The writer has bred out bracon flies from two scolytid bark-boring pests—*Scolytus major* and *S. minor*—which infest deodar trees in the North-West Himalayas. The flies appear to lay their eggs in or on the larvæ of the Scolytus. Fig. 99 shows a species of Braconid fly.

SERIES 2.—*Hymenoptera Tubulifera.*

Trochanters undivided; the hind body consisting of from three to five visible segments; the female with an ovipositor, which is usually tractile and envelopes a fine pointed style. The larvæ usually live in the cells of other *Hymenoptera*. This is a small group in comparison with *Parasitica* and *Aculeata* and is not of importance here. One family is recognised.

FAMILY VIII.—*Chrysididæ* (Ruby Wasps).

Insects usually of glowing metallic colours, with a very hard coarsely-sculptured integument; the antennæ are 13-jointed and abruptly elbowed. The abdomen is of peculiar construction and allows the insect to roll itself up into a ball; the terminal segments are telescopic and are usually drawn into the body.

The ruby-flies do not attain a great size; but are always noticeable owing to their brilliant colouring; they are often to be found flying about Indian verandahs in the sunshine. A common metallic green species with a blue sheen is *Chrysis fuscipennis* (fig. 100), to be found all over India and Burma up to 10,000 feet. This insect is parasitic upon three species of *Eumenes* (p. 71) laying its eggs in the larvæ of the wasps.

SERIES 3.—*Hymenoptera Aculeata.*

Trochanters undivided; abdomen consisting of six or seven visible segments; female has a retractile sting. Antennæ are usually 13-jointed in ♂, 12-jointed in ♀. There are numerous exceptions in the ants. The larvæ are legless grubs of soft consistence and live either in cells or, in the case of the social forms, in the abodes of the parents. The larvæ of the ants and fossorial aculeata have the anterior

parts of the body long and narrow and abruptly bent so that their heads hang down. The pupa is always soft and gradually assumes the colour and hardness of the perfect insect. The bees, ants, and wasps are included here.

FAMILY IX.—*Apidæ* (Bees).

Usually very hairy insects, with elbowed antennæ (*cf.* figs. 101, 103); the parts of the mouth are elongated to form a protrusible tubular proboscis (fig. 104); the hind body is never narrowed at the base into an elongated stalk as is the case in wasps and fossores (*cf.* fig. 103 and fig. 112); the basal joint of the hind foot is elongate, the tibiæ and tarsi of this leg being usually broad (*cf.* fig. 103, b).

There are no wingless adult forms amongst the bees; in the species which live in societies or colonies barren females, called workers, exist and carry on the work of the community. The food of bees is always obtained from the Vegetable Kingdom or from other bees. It usually consists of pollen worked up in various ways, and in this connection the hind legs of bees are of considerable importance since they are largely used in the industrial occupations of these indefatigable creatures, and in the female act as receptacles for carrying pollen to the nest. The tibia and the first joint of the hind foot are the parts most modified. Pollen is carried, however, by other parts of the body in many bees. The pollen is either carried to the nest in a dry state, in which case the hind legs are densely hairy, or it is made into a mass of a clay-like consistence when there are pollen plates present.

As is well known, bees frequent flowers, but not to gather honey as is usually thought. They really extract the nectar which is almost pure saccharose. This they swallow and bring it up again in its required state. Probably all bees eat pollen whilst collecting it, and it is the pollen collected mixed with honey which serves for the food of the colony.

The young of bees are always reared in cells and these cells (except in the case of the parasitic bees) are built by mothers or workers. The solitary bees store the cells with food and close up each cell after having laid an egg in it, so that in these cases the grub feeds upon a store of food previously provided for it. The social or colonial

bees (those living in hives, open combs, etc.) do not close the cells in which the larvæ are placed, but are fed by the workers very much in the same way that nestling birds are fed by the parents. The food is honey and pollen mixed in proportions which vary for different species ; the honey seems to be specially suitable to the young larvæ, as those bees which make closed cells place on the top of the mass of food a layer consisting principally of honey, which layer is first consumed by the young grub. The larva reaches its full size in a very short space of time, but rests for a more or less prolonged period before transforming into the pupal stage. The pupa shows the antennæ, wings, legs, etc., of the perfect insect very distinctly, the development of the latter being quick. Some larvæ spin cocoons, others do not.

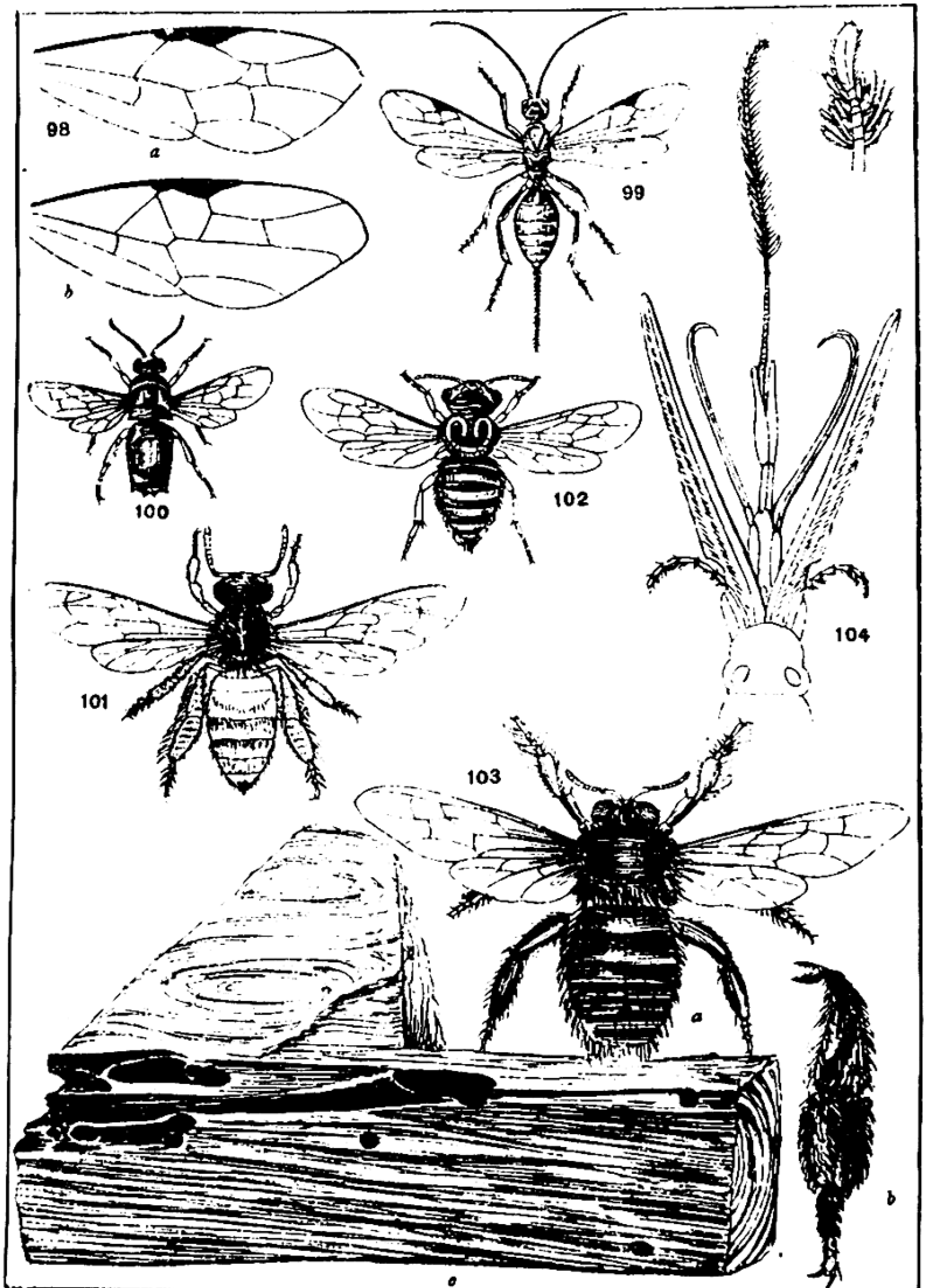
There are a large number of parasitic bees, *i.e.*, bees which lay their eggs, either one or more, in the cell of a working bee of a different species. The larvæ developing from these eggs grow more rapidly than those of the host and so cause the latter to die of starvation. In some cases the parasitic larva ends by consuming the grub it has robbed, before pupating.

It will be sufficient for our purpose here to consider the following groups:—

The PARASITIC bees (DENUDATÆ), CARPENTER bees (SCOPULIPEDES) MASON and LEAF-CUTTING bees (DASYGASTRES), and the SOCIAL or COLONIAL bees (SOCIALES).

The PARASITIC bees (DENUDATÆ) are long-tongued solitary bees with no pollen-carrying apparatus. They lay their eggs in the cells of other bees and often have a great resemblance to their hosts. Among those known in India are *Stelis parvula* and *S. cornuta*, the latter being shown in fig. 102. Nothing is known of their habits.

The SCOPULIPEDES include the Carpenter bees (*Xylocopa*), long-tongued solitary bees which are not parasitic. The genus Xylocopa contains many of the largest and most powerful of the bees and is well represented in India. They are often black or blue-black in colour (some species in India have a brilliant canary yellow thorax, whilst others have bright yellow and red abdomens), of broad robust build, with shining integuments more or less covered with hair. They are known as carpenter bees from the habit possessed by



P. M. & Litho. Dept., T. College, Roorkee.

Photo.-Zinco., November, 1906—No. 2847. 4.

98. Diagram of wings of Ichneumon (*a*), and Braconid (*b*) flies (after Sharp).
98. A Braconid fly.
100. *Chrysis fuscipennis.*
101. *Apis dorsata.*
102. *Stelis cornuta.*
103. *Xylocopa latipes.* *a*, fly ; *b*, enlarged leg ; *c*, galleries made by bee in Padouk wood.
104. Protrusible tubular proboscis of a bee.

[to face page 64.

some of them of boring into dry timber. They will not touch living wood nor will they tunnel into rotten wood. Sound seasoned timber appears to be what they prefer. They bore a cylindrical tunnel into the wood from which three or four parallel galleries give off in which broad cells are placed. These cells are always isolated by a partition formed by cemented fragments of wood which are cut out by the bee. Little is known about the life-histories of our Indian species, nor do we know how many generations they pass through during the year. *Xylocopa latipes*, depicted in fig. 103a, is a large dark blue and green *Xylocopa* widely distributed throughout India and ranging down into China and the Malayan region. It tunnels into sâl wood in the Bengal-Duars, occasionally causing serious damage to the rafters of the tea factories and other buildings, whilst it has also been found boring into padouk, imported from Rangoon, in Calcutta (fig. 103 c) and into teak in Rangoon.

Xylocopa chloroptera is the common carpenter bee of East India, Burma, Moulmein, etc. It selects hollow bamboos for its cells, connecting together pieces cut out of the interior partitions of the bamboo and using them as horizontal partitions inside the bamboo to separate the internal cavity into cells. This species is much infested with a small chalcid parasite (*Encyrtus*), of which as many as 300 specimens of the fly have been bred from a single larva of the bee.

The group DASYGASTRES includes the mason and leaf-cutting bees. In these bees the ventral surface of the hind body in the females is densely set with regularly arranged hairs by which the pollen is carried. In many, as in Megachile, the labium is very large and in repose is deflected on to the lower side of the head. This group includes some of the most interesting, and, perhaps to the general public, some of the best known of the solitary bees. The mason and leaf-cutting bees are well-known in India.

The leaf-cutting bees cut elongate or circular portions out of green leaves to form the partitions for their cells. A well-known Indian one is *Megachile anthracina* (*fasciculatis*), depicted in fig. 105. It cuts long pieces out of rose or pulse leaves and forms its cells of these, a circular piece being cut to serve as the lid. These cells resemble an ordinary sized thimble. Horne states that in one specimen examined by him thirty-two pieces of leaf disposed in seven layers were used for one cell, in addition to three circular pieces for the lid.

Some kind of gummy material is believed to be used to keep in place the pieces forming the interior layer. This is not, however, invariably the case, as in a species found by the writer in a tunnel in blue pine wood in the Himalayas the leaf pieces used were merely tightly wedged in their places. The cells are placed end to end as shown in fig. 106 a, b, five to seven cells forming a series; four to six series are believed to be constructed by one pair of this bee, the mass being placed in a hollow in masonry or some similar position. Each cell when completed is half filled with pollen and an egg laid in it (see fig. b). This bee is much infested by parasites and is also eaten by the Grey Hornbill (*Meniceros bicornis*). A Lower Burma species of *Megachile* makes its nest in the young shoots of teak saplings, entering by a hole at one side. One generation of the fly issues towards the end of January.

Megachile lanata, shown in fig. 107 a, is the common bee found in Indian houses, and especially verandahs. Horne states that both sexes take part in constructing the cells. These cells are formed of clay (fig. 107 b), and a hollow cavity of almost any kind will be made use of; the back of a book, an empty punkha-rope hole in the wall, the barrels of a rifle or gun, etc., are often found tenanted by the cells of this insect.

The Social bees (SOCIALES) include the genera Bombus, Melipona (Trigona), and Apis.

Bombus or the bumble bees are more like wasps in their habits than bees in that the societies die off at the end of the season, only a few females living through the winter, each of which starts a new colony the following spring. *Bombus orientalis* is a large black, yellow, and red bumble bee, very common about Darjeeling. It is shown in fig. 108. Males, females, and workers are present in the nests. Th se latter are found in the ground amongst moss, leaves, etc.

Melipona includes several species of very small bees which are common in India, although little is known about their life-histories. They are stingless bees, building their nests in old walls, etc.: the nest is formed chiefly of chewed resin. They produce honey and wax in considerable quantities, but no attempt has ever been made to domesticate them. *Melipona* (*Trigona*) *thoracica* (fig. 109) is common in Tenasserim. *M. indipennis*, another species, has been taken at Barrackpore near Calcutta and is also common in Burma.

The genus Apis contains the wild honey bees *par excellence* of India. In these bees we get the three forms of male, female, and worker. The males are the drones and do not work. Neither the male nor female take any part in the provision of food either for themselves or the young. The colonies are permanent, *i.e.*, they do not end at the close of a season, the formation of a new colony taking place by what is termed 'swarming.' This swarming of bees is not a nuptial flight as is usually supposed. The swarm consists of one female and a number of workers. These workers build the new comb. The comb consists of a number of hexagonal cells, consisting of wax, intact with one another at the sides. The queen lays an egg in each cell, and as these hatch the young larvæ are fed by the workers. Some of the cells are used for storing honey in. The fertilisation of the young queen takes place during a solitary flight after the swarm has settled down. Three species will be considered: *Apis dorsata*, *A indica*, and *A. florea*. *A. dorsata* is the big bee shown in fig. 101. It constructs large nests consisting of a single semi-elliptical comb of as much as five feet across and two feet deep, either suspended to the under-side of the branches of lofty trees or to portions of buildings or attached to the rocks of precipitous cliffs, as, for instance, at the Marble Rocks on the Narbada River near Jubbulpore and in the Ajanta Caves, Bombay. This bee can be recognised by its size and elongate body. Its sting is very poisonous, being most deadly in the hot weather and often resulting in death to Europeans if inflicted in numbers when the blood is in bad condition. That this is invariably so in the case of the jungle tribes of the country is doubtful, as the writer has seen Kols and Santals with many stings in their bodies, but apparently suffering no inconvenience therefrom. This bee is very difficult to dislodge, as it will return again and again to a chosen site, thereby greatly disfiguring buildings. Arches in the Taj Mahal at Agra were at one time greatly disfigured by the combs of this insect.

A. dorsata appears to be common all over the country and is found up to over 7,000 feet in the Himalayas. When disturbed it will attack, with the utmost fierceness, both man and animals. There is a considerable trade in its honey and wax, but to obtain them the comb has to be destroyed, and the natives are very careless in their

method of collection, pressing the whole into great balls containing pieces of twig, dirt, and other impurities. It is doubtful whether this bee can ever be domesticated. Should it prove possible, there can be little doubt as to the great commercial value it would have.

Apis indica (see fig. 110) is a smaller bee, whose habits are similar to those of the European *A. mellifica.* It builds in hollow trees, holes in walls, etc. Bingham states that in Burma, where no species of honey-bee is domesticated by the Burman, he has more than once seen a house (the houses are chiefly built of wood) rendered nearly uninhabitable by a swarm of *A. indica* taking possession of the hollows under the wooden staircases or of the space between the outer walls, when these were built double.

The honey of *A. indica* is particularly sweet, and attempts have been made to domesticate it in various parts of India, including parts of Bombay, the Kuram Valley, most districts of the Himalayas, and Assam. In the latter province the matter has been taken up by the Agricultural Department. The method of rearing as practised in the Khasi Hills is crude and not unlike the old system of rearing bees in skips practised at home. Attempts are being made to introduce the bar-frame hive.

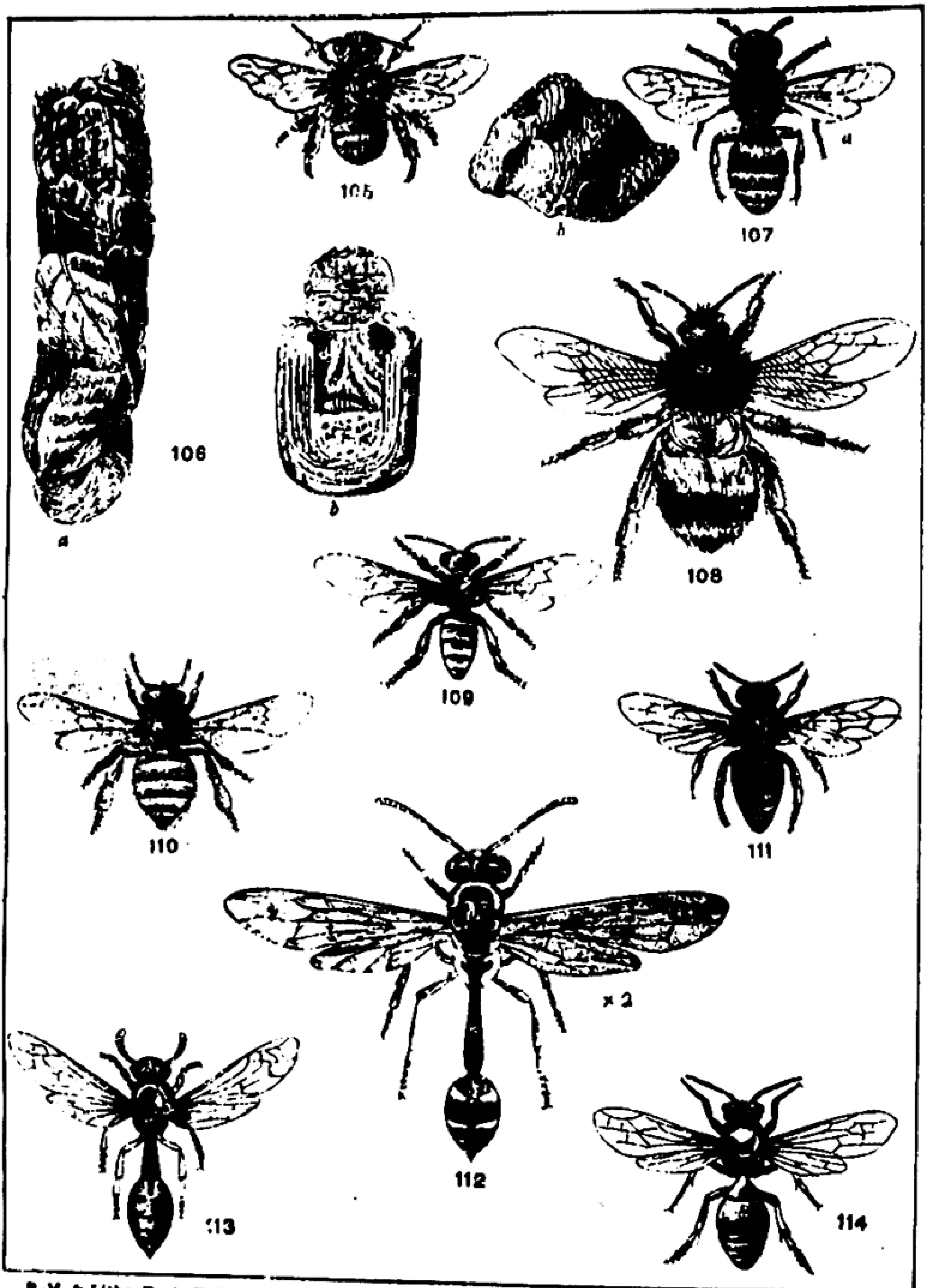
A. florea (fig. 111) is the smallest of the bees; it is about the size of a small house fly and builds its single comb on the branches of trees or in bushes or under the eaves of houses. Its honey is very sweet, but is in too small a quantity to be worth cultivation.

FAMILY X.—DIPLOPTERA (VESPIDÆ) WASPS.

The wasps can be easily distinguished by the fact that when they are at rest the upper wings are longitudinally plicate, that is, longitudinally folded down the middle. This is well depicted in Sharp's drawing of *Eumenes flavopicta*, a Burman solitary wasp shown in fig. 112. The trochanter is simple, the antennæ elbowed, the eyes reniform, and the mandibles long and projecting.

The wasps are either solitary or social, and some have the three forms: males, females, and workers.

The solitary wasps (*Eumenidæ*) are more numerous than the social ones, though perhaps less noticeable. They may be distinguished by having the claws of the foot bifid, the middle tibiæ having only one spur at the end. There are no workers.



P.-M. & Litho. Dept., T. College, Roorkee. Photo.-Zinco., November, 190[illegible]—No. [illegible]

105. *Megachile anthracina* (Leaf-cutting bee).
106. Nest of leaf-cutting bee. *a*, part of a row of cells; *b*, section of cell showing lid raised and larva inside.
107. *Megachile lanata*. *a*, bee; *b*, clay cells occupied by larvæ.
108. *Bombus orientalis*.
109. *Melipona thoracica*.
110. *Apis indica*.
111. *Apis florea*.
112. *Eumenes flavopicta*.
113. *Eumenes conica* (common Indian Solitary wasp).
114. *Odynerus punctum*.

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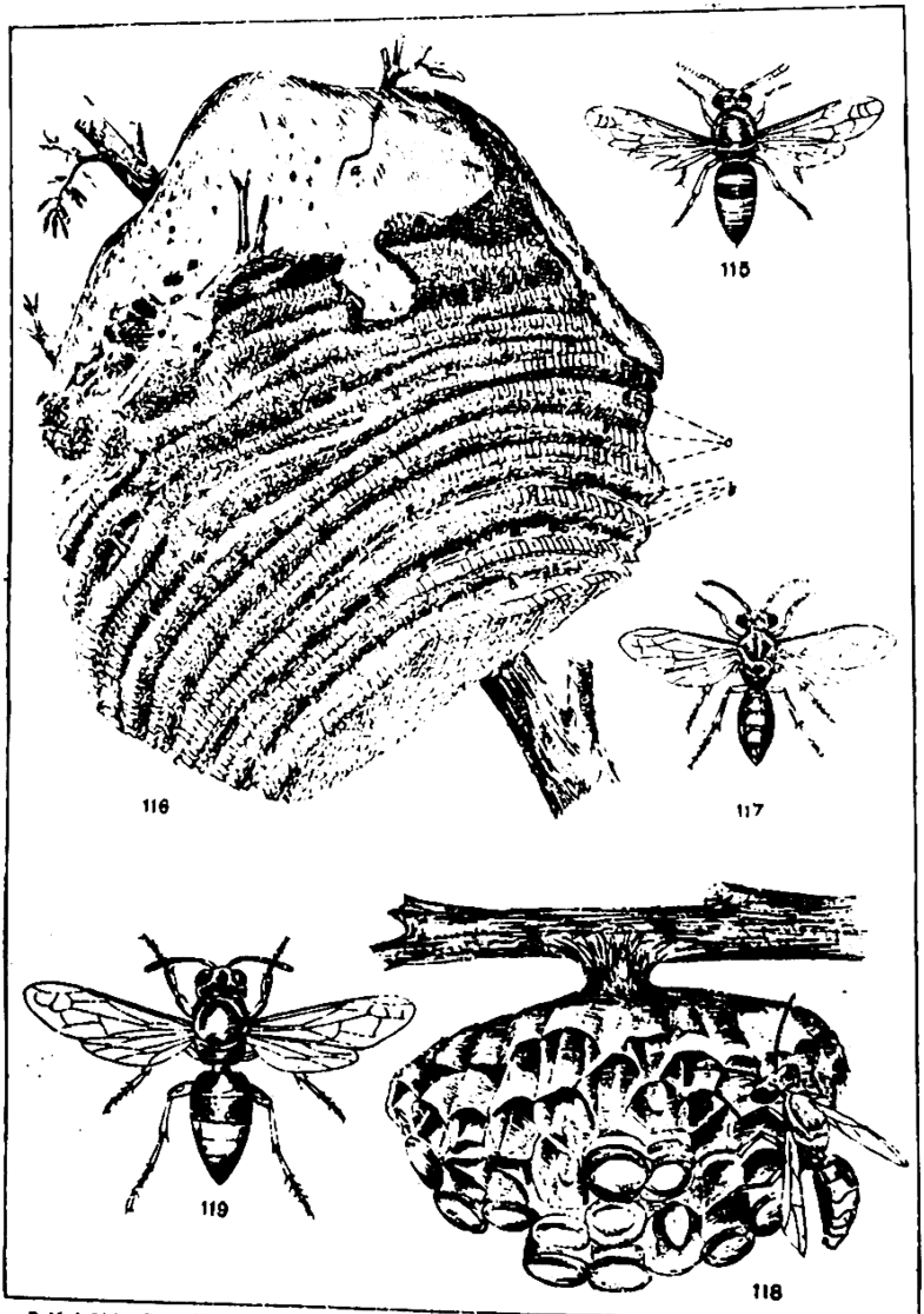
A common Indian solitary wasp is *Eumenes conica* (fig. 113) which constructs clay nests with very delicate walls. In these nests about a dozen green caterpillars are placed in a mass together, there being only one cell. It apparently usually selects light-green caterpillars for provisioning the nest with, although occasionally dark coloured ones may be found. An egg is laid in the nest and the larva on hatching out feeds upon the caterpillars. This wasp is much attacked by parasites, one of which is the cuckoo-wasp, *Chrysis fuscipennis*, mentioned above. *Odynerus punctum*, another Indian species shown in fig. 114, makes use of holes in door posts, etc., especially vacant ones made by large nails or screws. The hole is filled with provisions and the orifice is then covered over level with the surface of the wood so as to escape observation. This genus is said to be destroyed by *Chrysididæ*. The members of the genus Rhynchium also prey upon insects, usually selecting the interior of stems for their nests. *R. brunneum* (fig. 115) makes use of hollow bamboo stems. Horne records a case in which a female of this species took possession of a stem in which the bee *Megachile lanata* had already built two cells. The wasp first constructed a partition of wood over the spot occupid by the bee, this partition being similar to that which it makes use of for separating the space intended for his own young. This species stores caterpillars intended for its young, and this is also the habit of another Indian species, *R. nitidulum*. This latter wasp constructs clay cells, similar to those of *Eumenes*, which it fixes firmly to wood.

The social wasps (Vespidæ) live in colonies, as in the case of the social bees, consisting of males, females, and workers. They build ingeniously constructed nests consisting of a paper-like substance composed of chewed wood or bark. These nests consist of one or more horizontal combs, each composed of a number of prismatic hexagonal cells open at their lower ends. These contain the larvæ, one in each, which thus hang head downwards. The whole nest may be surrounded by a firm or loose covering. The larvæ are fed upon chewed insects. The whole population of the nest dies in the late autumn, with the exception of the young fertilised females. These survive through the cold weather months, and in the spring set about

founding a new colony. The female commences the new nest by partially constructing a few cells and laying an egg in each (*cf.* 118). She then continues the building work until the young larvæ hatch out. These she is supposed to feed upon saccharine matter at first, subsequently giving them chewed insect food. In the intervals she continues the construction work and egg-laying. This, however, naturally progresses slowly as long as the larvæ have to be fed. When these latter are full fed they pupate, and after a short time spent in this stage the adults issue and at once carry on the construction of the nest, as also the feeding of the larvæ, and perhaps of the female herself who no longer engages in any work save egg-laying. The adult wasps feed chiefly upon sugary matter and fruit.

The nests of the Vespidæ are very elaborate structures formed of quite a different material to those of the bees. These latter, as we have seen, secrete wax and use it to build the comb, whereas the wasps make use of paper or card which they form from fragments of vegetable tissue, more especially woody fibre, amalgamated by means of cement secreted by glands; these vegetable fragments are obtained by means of the mandibles. In the case of our Indian wasps' nests the whole is enveloped in so solid and beautifully constructed an envelope of papier-maché (fig. 116 a) that they are enabled to pass through the heavy monsoon rains without injury. In most of the nests of the Vespidæ the comb containing the larval cells (c) is placed in stories, one above the other, the stories being in some cases held up by pillars (b) made by the wasps, supported either by a branch or by the outside envelope, communication being effected by a hole in each layer of the comb, *e.g.*, as in *Vespa velutina* (fig. 116), or there may be only one mass or comb, as, *e.g.*, in *Polistes* (fig. 118). The eggs are laid in the cells when the latter are only partially formed. The subsequent building up of the cell being accomplished as necessitated by the growth of the larvæ. The changes to pupa and imago take place after the cell has been entirely closed.

Perhaps the commonest of Indian social wasps is the yellow *Polistes hebræus* (fig. 117). Everyone knows the beautifully constructed papery nests of this insect. This wasp is particularly addicted to buildings and will attach its nests to rafters, door frames, in fact woodwork of any description or to almost any convenient spot



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115. *Rhynchium brunneum.*

116. Nest of the wasp, *Vespa velutina.* *a*, portion of the papier-maché envelope or covering (the rest has been removed); *b*, pillars supporting comb; *c*, stories or layers of the comb containing larval cells.

117. *Polistes hebraeus.*

118. Partially formed nest of *P. hebraeus* with a wasp clinging to it.

119. *Vespa orientalis.*

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from its own point of view. The nest is unenclosed in any envelope; the hexagonal cells form an irregular comb or mass which is attached by a stalk near its centre, or more correctly the nest is constructed from a central basal attachment, the cells being so placed that their mouths look downwards. Fig. 118 shows a partially formed nest of this insect with a wasp clinging to it.

Vespa valutina, the Indian hornet, builds nests of several feet in length, which are inhabited by a very large number of individuals. Fig. 116 shows a fine nest of this species. The outer envelope is partially removed to show the formation of the stories of the comb.

The Indian hornet is very fierce when roused and will follow its enemy for miles even through dense jungle. Its sting in the hot weather is dangerous and may have fatal results in a similar manner to that of *Apis dorsata*. *Vespa magnifica* is the common wasp of the Himalayas from Simla to Darjeeling, extending into the hills of Assam, Burma, and Tenasserim. *Vespa orientalis*, shown in fig. 119, is to be found in the Punjab and United Provinces.

FAMILY XI.—*Fossoria* (Sand-wasps).

Smooth-bodied insects, often long-legged and very like wasps, from which they are distinguished by having their antennæ curled and not elbowed. The front wings are not longitudinally folded.

In habits they resemble solitary wasps, constructing either cells of clay or burrows in the ground or tunnels in the wood and stems of plants; others form no special receptacles for their young, being either parasitic or semi-parasitic, or making use of the abodes of other insects, holes, etc. The insects are carnivorous, the cells, holes, etc., being filled with insects which the female first stings and paralyses, to serve as food for her young.

The *Scoliidæ* are parasitic fossoria; they are large powerful insects with thick legs, usually black in colour with bands and spots of red and yellow. *Scolia procer* (fig. 120) is a common Indian and Burmese species. Little is known about its habits.

The *Sphegidæ* form their nests in burrows or construct mud cells. *Sphex lobatus* (fig. 121) provisions its nest with *Orthoptera* and the large noxious cricket *Brachytrupes achatinus* (*vide* page 42, *supra*) is said to be made use of in this manner. *Pelopæus* (*Sceliphron*) *madraspatanus* (fig. 122a), common in North India, is the common mud-dauber. It builds its elongate mud cells all over the house, the cells being 4-6 in number, and stocks them usually with about a score or so of spiders. The edifice when completed is disguised so as to look like a daub of mud.

Ampulex compressa (122 b) does not construct any special cell but makes use of holes which it provisions with cockroaches.

FAMILY XII.—*Formicidæ* (Ants).

The ants can be distinguished from other Hymenoptera by the fact that they have a construction in the stalk which joins the abdomen to the thorax. The antennæ are elbowed; the trochanters are undivided. The individuals of each species are usually of three kinds: males, females, and workers; the latter have no wings, but the males and females are usually winged, though the females soon lose their flying organs. They are social insects living in communities of various members, the majority being workers. The larvæ are helpless maggots, fed and tended by the workers or by the female. The pupæ are enclosed in silken cocoons. These are the so-called 'ants' eggs,' which may be seen in fine weather exposed on the top of the nest to the warmth of the sun's rays.

Ants build nests which consist of passages and chambers dug out in earth and rotten wood, stumps of trees, etc., or they build in the crowns of trees or bushes amongst the leaves which they fasten together. The burrowing ones generally pile up the earth they dig out in hillocks above the surface level.

The two most important sub-families of the ants are the *Formicides*, which have only one knot in their peduncle (fig. 123 A, a), the abdomen being usually not furnished with a sting, and the *Myrmicides*, with two well-marked knots in the peduncle (fig. 123 B, a, b,) the abdomen being usually furnished with a sting.

An example of the Formicides is the large vicious red ant, Œcophylla smaragdina, of India. This ant inhabits trees, making a nest of the leaves which are fastened together. The ant itself has no material with which to fasten the leaves, and so makes use of the larva which possesses glands secreting a sticky substance. Several ants pull the leaves together while others holding the larvæ in their jaws as shown in fig. 124 use them to moisten the edges of the leaf. This ant is a common insect in the sâl and other forests of India.

The large black ant, *Camponotus compressus* (fig. 125), which constructs its nests in the ground is another common example of the *Formicides*. *Camponotus* attacks other ants, and is to be found in attendance upon *Aphidæ* and *Coccidæ*; it kills the lac insects, often causing serious injury in lac areas. One species has been found sucking the sugary secretion emitted by the Dun sâl *Monophlebus* scale-insect. Among the *Myrmicides* may be noticed a large fierce ant, *Sima rufonigra* (fig. 126), called the sepoy ant in Madras from its colouration, the insect having a red thorax and black head and body. It makes its nest in dead

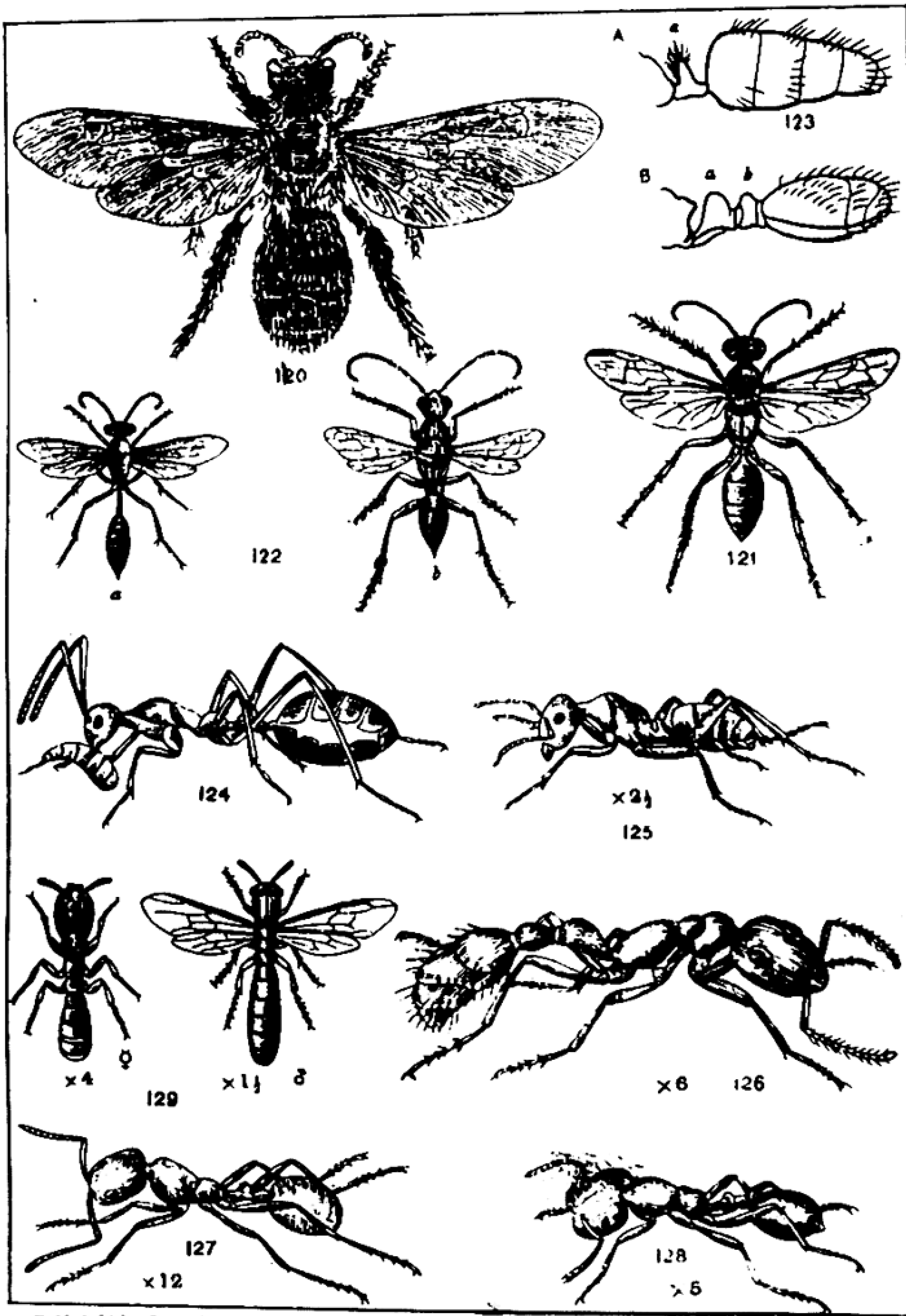

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Photo.-Zinco., November, 1908.—No. 6317.

120. *Scolia procer.*

121. *Sphex lobatus.*

122. *a*, common mud dauber (*Pelopœus madraspatanus*) ; *b*, *Ampulex compressa.*

123. Abdomens of Ants A. Formicides, with one joint, *a*, to peduncle. B. Myrmicides, with two joints, *a*, *b*, to peduncle.

124. *Œcophylla smaragdina* (common Red Ant). A worker using a larva for spinning purposes.

125. *Camponotus compressus.*

126. Sepoy Ant (*Sima rufo-nigra*).

127. *Solenopsis geminatus.*

128. *Holcomyrmex scabriceps.*

129. *Dorylus orientalis.*

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wood, and is often found in old longicorn borings in sandal wood trees in Coimbatore and Mysore. Its sting is very painful. It is equally common in the north of India. Bingham writes: 'S. rufo-nigra makes its nest in the dead wood of trees and very often, in Burma at least, in the clefts of the beams and posts of the wooden rest-houses scattered over the country. Personally I opened and examined only one nest and that was in a hollow in a Pyinkado tree. The hollow was low.' The common red ant of the plains of India is *Solenopsis gemminatus* (fig. 127), which lives in large colonies in nests in the ground, under stones, etc. It constructs partially covered ways across roads and is often to be seen carrying off dead insects. It has been reported as attacking potatoes and may be found to do damage in nurseries. A largish ant with reddish head and dark abdomen, called *Holcomyrmex scabriceps* (fig. 128), is a granary ant and builds its nests in the ground and stores up grass and other seeds. Quite large heaps of grain are collected by these insects, which they may feed upon or simply allow to ferment and then feed upon the sugar contained in the fermenting mass.

The sub-family Dorylinæ with large yellow-winged males and small flattened yellow workers are carnivorous hunting ants. There is a curious exception to this rule in the sub-family, however. The ant *Dorylus orientalis* (fig. 129) feeds upon vegetables, it having been observed attacking both potatoes and cornflour plants in the Botanical Gardens at Calcutta.

Some ants are in the habit of keeping Aphidæ (plant lice) in their nests, which they use much as we use cows, sucking up the sugary secretions they emit.

Useful Hymenoptera.

The *Hymenoptera* contain several families of useful insects which tend to keep injurious insect pests, both in the forest and field, in check. It must, however, be borne in mind that the good is in some cases almost counterbalanced by the fact that the same families contain insects which are parasitic upon, and therefore keep in check, our useful insect friends. In spite of this, however, in the case of serious increases in the number of an insect pest, such as plagues of caterpillars, man is deeply indebted to his hymenopterous allies.

The Order may be divided into four groups :—

(*a*) Insects useful because they are parasitic upon noxious pests.
(*b*) Insects harmful because they are parasitic upon useful insects.
(*c*) Insects of use to man because they furnish him with certain articles of economic use, as food, etc.
(*d*) Insects of indirect benefit to mankind in that they largely aid in the fertilisation of plants and thus perform an important part in the economy of nature.

Amongst the families in group (*a*) the *Chalcididæ* without doubt contain numbers of insects of great use, and their further study will well repay the trouble expended on it. Undetermined species have been already found attacking

bark-borers, such as the blue pine *Polygraphus*, *Pityogenes*, and the deodar *Scolytus* beetles, and this is but a commencement in the great field ready for exploration. The next family of use to man are the *Ichneumonidæ* or ichneumon flies, which are *par excellence* a parasitic group, and more especially attack the caterpillars of *Lepidoptera*. Numerous wild silkworms are subject to their attacks, and amongst forest defoliating caterpillars kept in check by them may be mentioned *Lymantria* (several species), *Dasychira*, *Acronycta*, *Hyblæa puera*, etc. Future observations will add many more to the list. The family are of use also in keeping the wood-boring grubs, both coleopterous and hymenopterous, in check, the genera *Rhyssa* and *Thalessa* being of particular importance in this respect. A species of one of these genera is parasitic upon the Indian spruce sirex. The *Braconidæ*, or supplementary ichneumon flies, as they are sometimes called, resemble in habits the *Ichneumonidæ*, and they are of interest in the forest, since already species have been found parasitic on the larvæ of the *Scolytus* deodar bark-borers, and researches will probably show that there are many other similar cases.

The *Diploptera* (wasps) and the *Fossoria* (sand-wasps) both paralyse and lay their eggs in caterpillars and other insects, and therefore are of some use in keeping down pests. The sand-wasps also attack grasshoppers, probably several times their own bulk, and lay their eggs in them.

Little is known about the *Scoliidæ* in India, but in Madagascar a species lays its eggs in the rhinoceros beetle (*Oryctes*) which attacks palms. It may be found that a species infests and keeps in check the *Oryctes* in India where it is a serious pest at times.

Amongst the *Formicidæ* present available information does not show that they are of much use. The bamboo ant, *Œcophylla smaragdina*, feeds largely upon caterpillars, and so is possibly of some use in keeping down defoliating pests.

An example of group (*b*) is the chalcid fly, *Perilampus* sp., which is parasitic upon the useful Tachnid flies (*Trycolyga* and *Masicera*) which parasitise the caterpillars of noxious species of *Dasychira*.

The *Apidæ* must be classed amongst the useful *Hymenoptera*, not on account of any predatory habits, but owing to the fact that they furnish man with certain products, such as honey and wax, which add to his food and comfort. There is yet another and important part played by this family in nature. Bees undoubtedly help largely in the distribution of pollen, and therefore in the fertilisation of the flowers of trees and shrubs, and consequently in the continuance of vegetable growth. It is not improbable that the family is of great service to the forester in this way.

Taken as a whole, the Order may be looked upon as one of considerable utility to man.

Chapter VII.

Order V.—Coleoptera.

The Coleoptera or Beetles appear to be wingless insects, but have really four pairs of wings. The upper pair, which are called the 'elytra,' are hard and horny and shell-like, fitting accurately together over the back, thus protecting it and the lower wings, which are folded beneath them and are membranous. Fig. 130 shows a beetle with the right elytra in the position of rest, the left one being held up so as to set free the under wing. In the mouth mandibles are present, and the lower lip is divided along the middle. The metamorphosis is complete. The larva is grub-like, and changes to a pupa in which all the parts of the perfect insect are distinguishable, but are still white and soft.

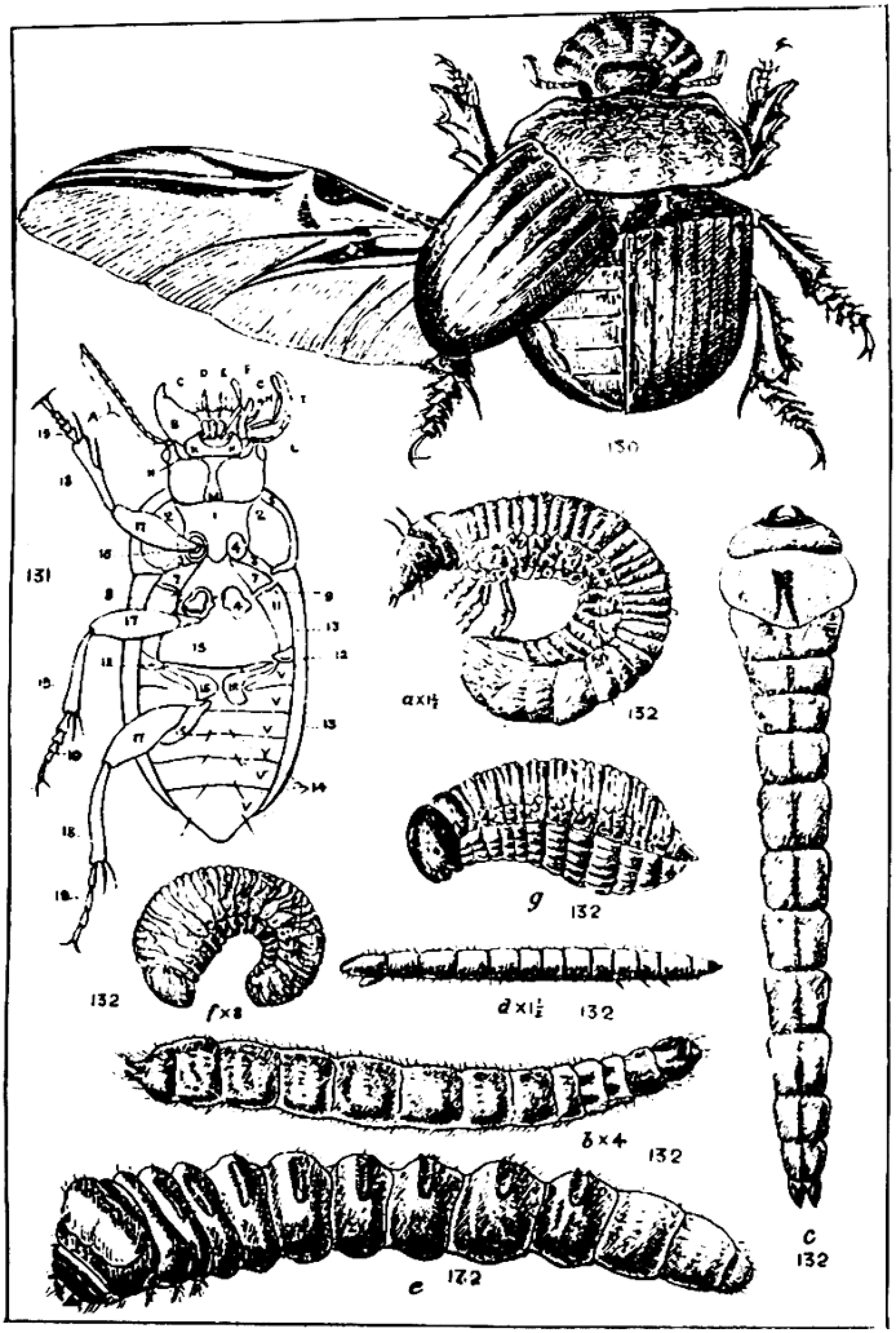
The beetles are one of the largest and most important of the Orders of Insects as well as being one of the most injurious in the forest. Both larvæ and imagoes bore into the bark and timber of the boles of trees (and also into the branches and roots) and lessen or destroy their value. They also girdle branches and kill them, feed upon and defoliate the leaves, and burrow into and destroy the seed.

Beetles are chiefly distinguished from other insects by the solidity of their outer covering and by the peculiar nature of their first pair of wings, which are not used as instruments of flight, but merely serve to protect the hinder part of the body. Beetles are not found on the wing as much as other insects, and therefore, notwithstanding their enormous numbers, they are not met with so frequently as ants, bees, flies, etc. The number of species at present known is probably about 160,000 or thereabouts, and their habits are so varied that they can be found everywhere when looked for.

The general form varies much from flat-spherical to long-linear. The head is well developed, with a biting mouth; compound eyes are present, which are not uncommonly divided. Ocelli (simple eyes) are rare. Antennæ eleven-jointed or with fewer joints. These latter are variable in shape and are of importance in classification. The structure of the hard parts of the skeleton is of importance

since the classification of the species is entirely based upon it. The prothorax is very free and is therefore capable of considerable movement independent of the after-part of the body. The meso-thorax is much reduced. The meta-thorax is largely developed in winged forms. Fig. 131 shows the under surface of a beetle with the different parts named. It is essential that the student of the Coleoptera should make himself thoroughly acquainted with the nomenclature of the different parts. The elytra frequently have a remarkable sculpture, the use of which is unknown. When the elytra are shut up, they cover the greater part of the meso- and meta-thorax, abdomen, and the lower wings. At the basal point of juncture of the elytra there is a triangular portion called the *scutellum*, which forms the upper part of the meso-thorax. The elytra may leave a few of the posterior segments of the body exposed. These elytra are of such importance to the beetle that they are even present in cases where there are no lower wings. When this occurs they are often joined together down the central suture so as to form one piece, though the line representing the junction is always present. When a beetle flies the elytra open slightly upwards, letting free the lower wings (*vide* fig. 130). In the common rose-chafer (the green metallic-looking flat beetle to be found upon roses) where the elytra are joined together, they are merely lifted up; when the elytra are absent, as occurs in some beetles (*Tenebrionidæ*, etc.), there are no lower wings present. The nervures or veins in the lower wing are broken up to allow of their being folded up under the wing covers. The number of tarsal joints present varies from 2—5. One may be hidden and is only seen on dissection. For classification purposes only those visible are counted. Some of the tarsal joints may be bi-lobed; they are set with a spongy felt-work of hair to help the insects to walk upon plants. Only 5—6 segments of the abdomen are visible.

There is often a considerable difference in the sexes amongst beetles. There may be either a difference in size, the ♂ being smaller than the ♀, or an increase in size of the antennæ in the males or an enlargement of the interior tarsi; occasionally the number of joints of the tarsi vary in the two. The only music produced is chirping or squeaking by rubbing two files together. Phosphoretic organs are present in glow-worms and fire-flies. These consist of masses of cells connected



130. A Coleopterous Insect *(Heliocopris dominus)*. The right elytra is in the position of rest, the left one is elevated allowing the lower wing to be spread out in the position of flight.

131. Under surface of a beetle (legs and antenna of one side and some parts of mouth removed.) A. antenna; B, mandible; C, labium; D, ligula; E, paraglossa; F. labial palp; G, inner lobe of maxilla; H, outer lobe of maxilla; I, maxillary palp; K, mentum; L, gena; M, gula; N, buccal fissure; V, plates of ventral segments 1, Prosternum; 2, prosternal episternum; 3, prosternal epimeron; 4, anterior and middle coxal cavities; 5, inflexed side of prothorax; 6, mesosternum; 7, mesosternal episternum; 8, mesosternal epimeron; 9, metasternum; 10, posterior division of metasternum or ante-coxal piece; 11, metasternal episternum; 12, metasternal epimeron; 13, epipleuron or inflexed margin of elytron; 14, ventral or ambulatory setæ; 15, trochanter; 16, posterior coxa; 17, femur; 18, tibia; 19, tarsus. (After Sharp).

132. Coleopterous larvæ. *a*, *Lachnosterna ? sp.* (Scarabæidæ); *b*, *Thanasimus himalayensis* (Cleridæ); *c*, *Sphenoptera gossypii* (Buprestidæ); *d*, *Elater sp.* (Elateridæ); *e*, *Hoplocerambyx spinicornis* (Cerambycidæ); *f*, *Scolytus minor* (Scolytidæ); *g*, *Cyrtotrachelus longipis* (Curculionidæ).

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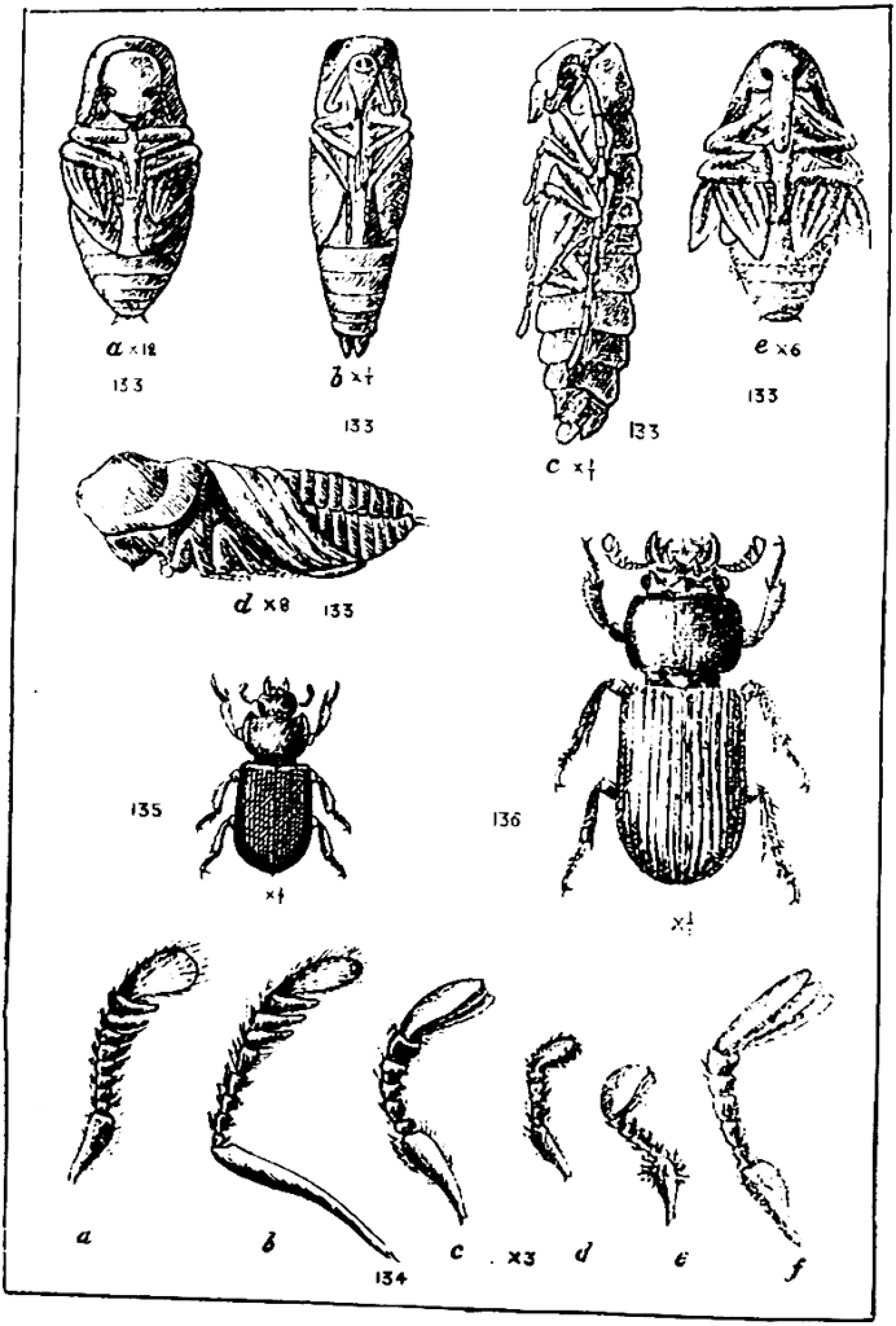

133. Coleopterous pupæ. *a*, *Dinoderus minutus* (Bostrichidæ); *b*, *Sphenoptera gossypii* (Buprestidæ); *c*, *Hoplocerambyx spinicornis* (Cerambycidæ); *d*, *Tomicus sp.* (Scolytidæ); *e*, *Calandra sculpturata* (Curculionidæ).

134. Types of Lamellicorn antennæ. *a*, *Pleurarius brachyphyllus* (Passalidæ); *b*, *Lucanus lunifer* (Lucanidæ); *c*, *Heliocopris dominus* (Coprides), *d*, *Lachnosterna impressa* (Melolonthides); *e*, *Oryctes rhinoceros* (Dynastides); *f*, *Agestrata orichalcea* (Cetoniides).

135. *Leptaulax dentalis.*

136. *Pleurarius brachyphyllus.*

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with a fatty body and are freely supplied with air. The light produced is caused by the oxidation of proteid matter. These organs are situated on the abdomen.

The larva is grub-like, with a distinct head and jaws; sometimes antennæ and six legs are present. They have no special boring apparatus and the sexes are distinct. They usually feed at night and upon all sorts of substances. Beetle larvæ are sometimes parasitic upon other animals, but this is not usual.

Owing to the difficulty in rearing Coleoptera less is perhaps known about their life-histories than of those of other insects. In India, until within quite recent years, the information on this subject was practically non-existent. As will be seen from descriptions in the following pages and in fig. 132, the larvæ of the Order vary considerably in appearance.

The pupa or nymph is quiescent and usually enclosed in a rough cocoon. It is usually white in colour; fig. 133 depicts various coleopterous pupæ. The adult may live near the cocoon without movement for some time after emergence whilst its outer layers of chitin are slowly hardening (this will be found common amongst ***Buprestidæ***, ***Cerambycidæ***, and the bark-borers, ***Scolytidæ***). The beetle when found in this condition in the pupal chamber is yellow or light brown in colour, changing to dark brown or black before it finally emerges from the tree

The initial classification of the Coleoptera depends upon the number of tarsal joints present on the feet. There are four great groups, and these groups are again divided into series as follows:—

Pentammera, 5 tarsal joints present on all the legs.

- *Series Lamnellicornia.*—Antennæ with the terminal joints broader on one side so as to form a peculiar club, the leaves of which are often movable.
- *Series Adephaga* or *Caraboidea.*—Antennæ filiform or nearly so.
- *Series Clavicornia.*—Antennæ usually thickened at the tip or knobbed.
- *Series Serricornia.*—Antennæ usually serrate along their inner edge.

Heteromera, 1st and 2nd pairs of legs have 5 tarsal joints ; the 3rd pair have 4 only.	Black or brilliantly coloured beetles, often wingless. The families Tenebrionidæ and Cantharidæ only will be considered here.
Tetramera, 4 tarsal joints present on all legs.	*Series Phytophaga.*—Head not forming a definite prolonged beak. *Series Rhynchophora.*—Head more or less prolonged in front to form a snout or beak (rostrum).
Trimera, 3 tarsal joints present on all legs.	Small oval beetles, often spotted. The family Coccinellidæ only will be considered here.

PENTAMMERA.

Five tarsal joints on all the feet.

SERIES I.—*Lamellicornia.*

Antennæ with the terminal joints, called lamellæ, usually three in number (sometimes more), broader on one side, forming a club, the leaves of which are movable, but in repose look like one piece, as they are held close together. Fig. 134 shows several forms of lammellicorn antennæ. The families *Passalidæ*, *Lucanidæ*, and the *Scarabæidæ* are included here, the form of the leaves of the club of the antennæ varies in shape in these three families. The larvæ have a horny head, large jaws and three pairs of legs, and are thick, clumsy grubs with curved bodies, the last two segments being of larger size than usual and often swollen out in a bag-like manner (fig. 132 a). Many of them possess organs of stridulation. The larvæ feed on decaying vegetable matter, roots, or dung. They live either in the ground or in the decaying wood upon which they feed.

FAMILY I.—*Passalidæ.*

The upper lip is large and mobile ; and the mentum is deeply cut out in the middle. The antennæ curl upwards and the plates at the top are thus brought together. These beetles are usually shining-black in colour and are abundant in decaying wood in tropical forests. The

larva appears to have only four legs, the 1st pair being short processes which are used to produce sounds by scraping over a striated surface situated on the next pair of legs.

Leptaulax dentalis (fig. 135) is a common insect of this family with a black shining thorax and longitudinally ridged elytra. It is abundant in rotten wood in the Assam Duars forests and submontane tracts of Bhutan. It has been taken in sâl and semul.

Basilianus andamanensis is said to be common in rotten wood in the Andamans, and *Pleurarius brachyphyllus* (fig. 136) has been taken by the writer in rotten stumps in the Ootacamund Hills.

FAMILY II.—*Lucanidæ* (Stag-beetles).

The Stag-beetles are well known owing to the enormous horns present on the head. These horns are only greatly developed mandibles and are only present in the male beetle. The upper lip is small, and the mentum is not cleft. The antennal end consists of a fixed cone which is rigid and does not open and close (134 b). The male is usually larger than the female, but the individuals of both sexes vary greatly in size (*cf.* fig. 137). Five ventral abdominal segments are visible. The larva has the last two segments of its body swollen up in a bag-like manner (132 a) and lives in decaying wood and roots, spending several years of its existence in this stage. The pupal stage is a short one, but the perfect insect may remain quiescent for some time after changing from the pupal state before it becomes active.

The Indo-Malayan and Austro-Malayan regions are richest in these beetles.

The common Stag-beetle of India, to be found all through the outer Himalayas and submontane tracts, is *Lucanus lunifer*, a dark greenish brown beetle shown in fig. 137. The female is devoid of the enlarged mandibles of the male (fig. 138).

In the outer Himalayas the mature beetles are to be found in June and July. It is probable that they issue irregularly during the summer months, as the writer has found in July fully-developed larvæ just pupating and also mature beetles. Some years ago larvæ, probably those of Lucanus lunifer, were reported as tunnelling into green living oak trees in Naini Tal. Owing to their queer swollen bag-like extremities it is extremely improbable that these larvæ are capable of tunnelling into green hard wood. It is probable that if boring was done in hard oak timber, longicorn larvæ were responsible, and the stag-beetles may have taken advantage of the galleries to lay their eggs in the ones whose edges were rotting and thus becoming softer. The writer has found numerous instances of decaying oak, etc., stumps full of these larvæ, but no instance of hard green wood being infested. The larvæ take several years to reach their full size; they then pupate in a cocoon constructed of chips of wood.

Lucanus cantoris is another common species. It is to be found plentifully at elevations of 4,500 to 6,000 feet in the Eastern Himalayas in April in decaying *Betula cylindrostachys*, *Castanopsis tribuloides*, and *Symplocos theæfolia* trees. Beetles were taken in July. It is also present in the Western Himalayas.

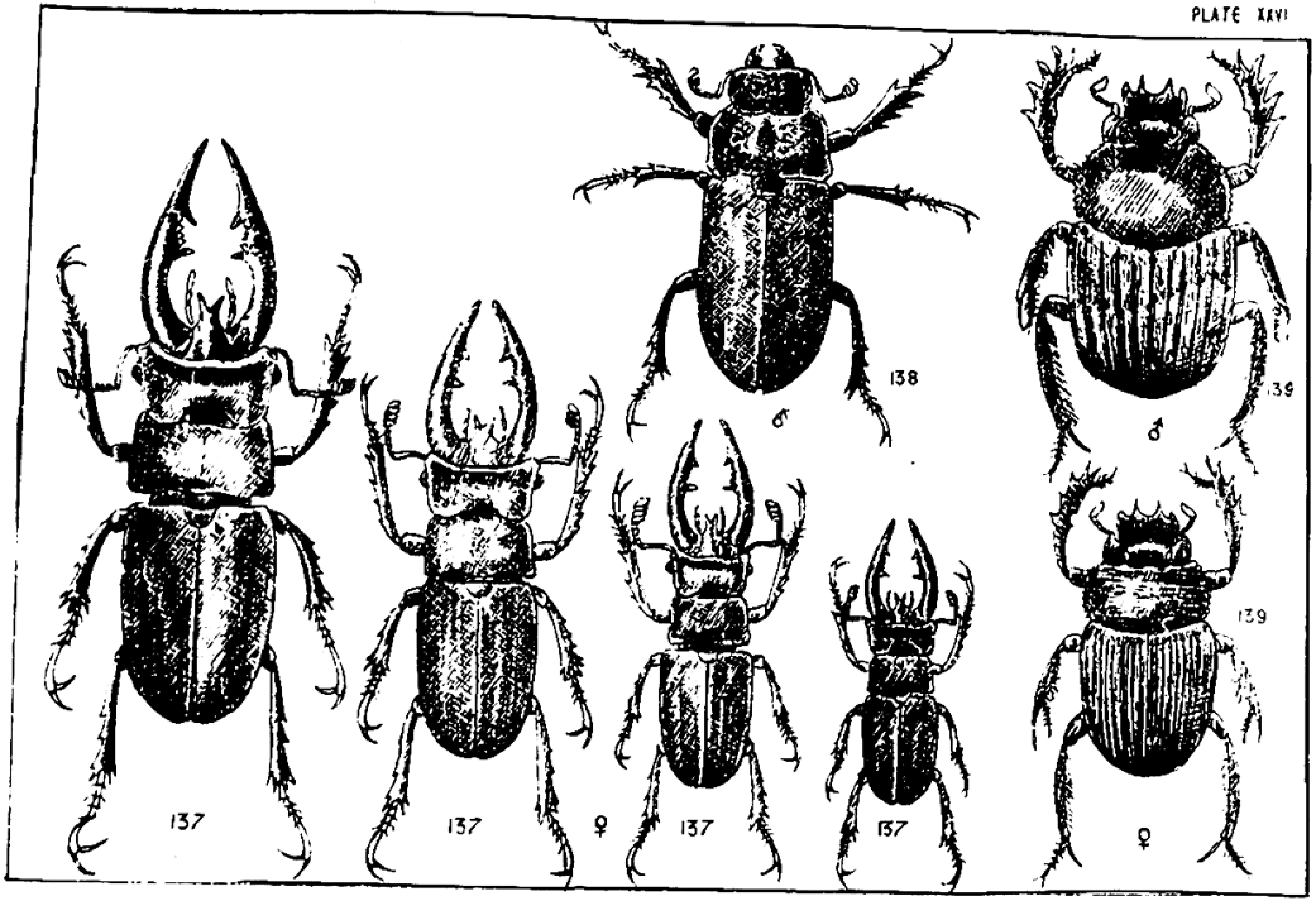
FAMILY III.—*Scarabæidæ* (Chafers).

The leaflets of the antennæ are freely movable plates which can be closed together at will by the insect (134c). The number of visible ventral segments of the abdomen is usually six or, at the sides, seven, never five as in the last two families. The elytra generally leave one or two of the last segments of the body exposed. The beetles of this family are bulky insects, having a powerful prothorax and front legs with flattened, spiny tibiæ adapted for digging, as, *e.g.*, in, *Scarabæus sacer* (fig. 139). At times the males are armed with long horns of various shapes growing out of the head and prothorax. The larvæ are bulky grubs resembling lucanid larvæ in shape. Both larvæ and adults feed upon plants and dung. The family is an important one amongst insects. About 13,000 species are already known. Several sub-families are distinguished, amongst which are the COPRIDES or dung beetles, MELOLONTHIDES or cock-chafers, DYNASTIDES or goliath beetles, and CETONIIDES or rose-chafers.

The COPRIDES or dung beetles are the well-known beetles found rolling balls of dung along the roads and commonly entering lighted houses at night. They are cumbersome, bulky insects with a heavy lumbering flight. They form a large group of beetles consisting of some 5,000 odd species. Both beetles and larvæ have the power of producing a stridulating noise by rubbing certain segments over one another. The hind legs of the beetles are long and are made use of in moving the balls of dung upon which they feed. The dung of the Ungulata forms the chief food of the group.

These beetles are plentiful in India, and although their habits have been little studied it is possible to give a fair idea of the habits of the vast majority. One of the largest members of the family is the elephant dung beetle, *Heliocopris dominus* (*vide* fig. 130). This insect is an inhabitant of Assam, an allied species *H. Mouhouti* being found in Burma and the Malays. The beetles feed on the dung of elephants. They cut off portions and form them into large balls of 3—5 inches across. These they then roll to a suitable locality and scooping out a hole in the soil push them in, get in after them, and then feed upon the ball. After pairing in June or July the female prepares a ball and buries it in the same way; she lays an egg in it and then covers up the ball with soil and refuse litter

PLATE XXVI



137. *Lucanus lunifer.* Common Stag beetle, showing great variation in size of male insect.
138. Female Stag beetle.
139. *Scarabæus sacer*, male and female.

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The grub on hatching out feeds upon the material thus provided, becoming full fed about January or February. It then pupates in the circular chamber in the soil once occupied by the ball of dung, but now entirely filled by the full-grown larva. The pupal stage lasts about three months or a little more, the beetle issuing in the monsoon period.*

Scarabæus sacer (fig. 139) is a well-known dung beetle of the country. These dung beetles play an important part in the economy of nature owing to the fact that they act as useful scavengers.

The MELOLONTHIDES are probably as numerous as the Coprides. Some 4,000 odd species are known, but many of the Indian forms are still uncollected. The beetles are all more or less square in build, of some shade of black, grey, brown, or dark green; the elytra always leave exposed two posterior segments of the body (pygidium), the last segment being more or less pointed. The male can be distinguished from the female owing to the fact that it possesses larger lamellæ to the antennæ. The grubs are straight when young, but curve into the thick bag as shown in fig. 132 a as they grow older.

All the Indian members of this group at present known feed upon the roots of plants and trees and are a source of considerable annual loss throughout the country to forester, planter, and ryot alike. The larval life often extends over several years, the time being spent by the grubs in feeding voraciously and growing in size, except during the winter months when they retire deep into the earth and more or less hibernate. The pupal stage is short, but the beetle may remain a considerable time in the ground before emerging, after leaving the pupa, to allow of the outer chitin hardening.

One of the best known pests of this group is the beetle *Lachnosterna impressa* or Indian cock-chafer, a thickish brown beetle of which the larva, pupa, and imago are shown in fig. 140, a, b, c. The larvæ of this insect live in the ground and feed upon roots of all kinds as far as present observations go. It moults its skin at intervals until it reaches full size, but never comes to the surface. The period spent in this stage probably exceeds a year. The grub is well known to planters as the 'White-grub.' It commits considerable havoc in nurseries of young tea plants. It appeared in vast quantities in the Darjeeling tea gardens in 1891 and committed a good deal of damage, being present in 1883 in the public gardens of the station itself and doing much damage. During this latter attack some 2,695,000 individuals were collected and destroyed. A large species

* For a fuller description of these insects, see 'Insect Life' in B. N. Hist. Soc. Journal. Vol. XVII, No. 2, pp. 434-437.

of *Lachnosterna* attacks young deodar seedlings in the forests of the North-West Himalayas, sowings of seed in patches in the forest often resulting in failure owing to this pest killing off the young plants by devouring the roots.*

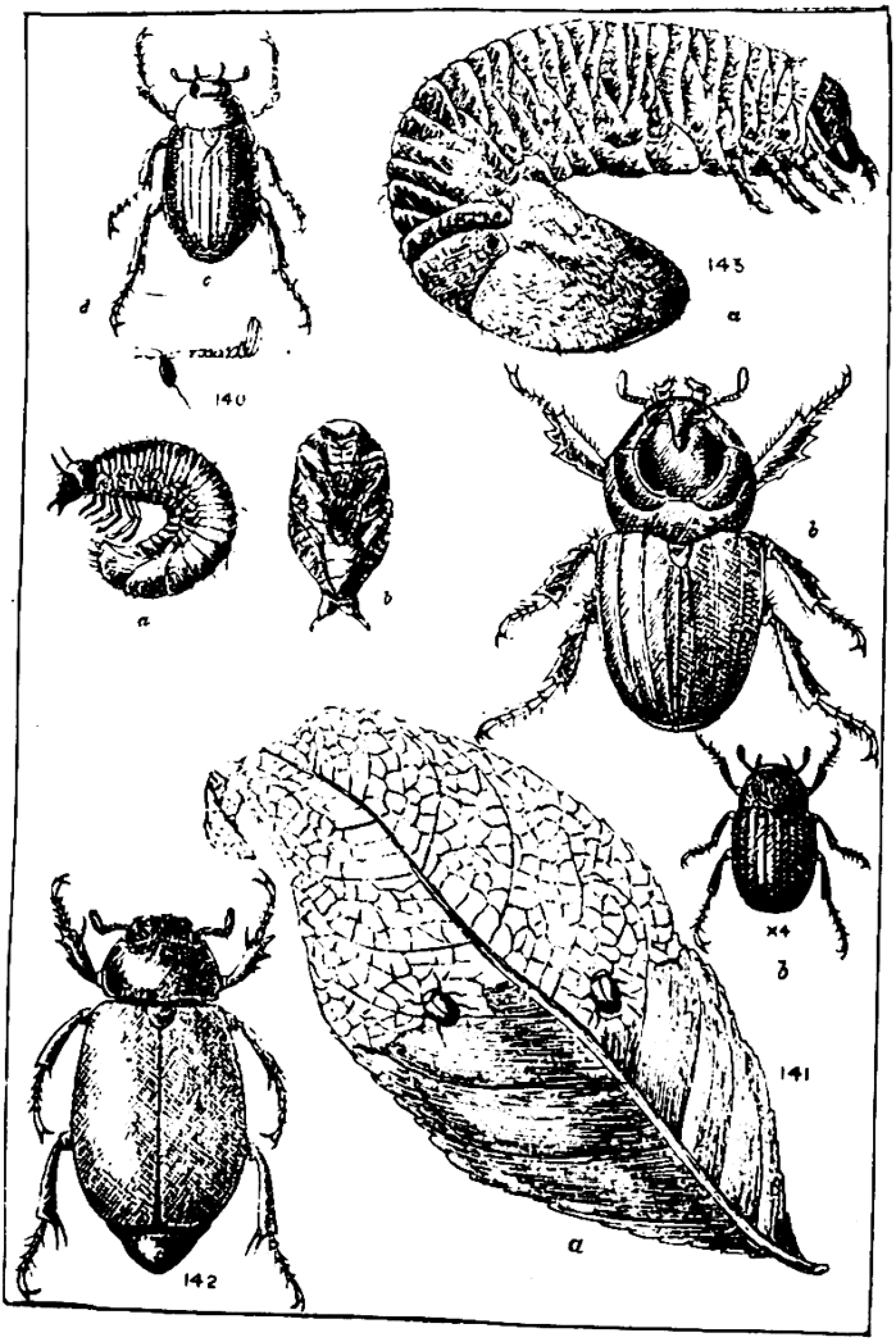
Lepidiota bimaculata is a large beetle with green thorax and brown elytra, from Assam (fig. 142). The genera *Serica, Adoretus, Anomala,* and *Holotrichia* contain many small melolonthid pests of which *Serica assamensis* and *Alcocki* (fig. 141) defoliate tea and *Mallotus philippinensis,* respectively. Species of *Adoretus* are pests to rose bushes in Southern India whilst *Anomala viridis* defoliates *Alnus nepalensis* in the Eastern Himalayas, its grubs feeding upon roots.

The DYNASTIDES include the largest of the beetles of this family, although numerically the group is the smallest, containing only about 1,000 odd species. The beetles themselves are large bulky insects, the males often having enormous projections and horns on their heads and prothoraces the use of which is at present but little understood. The males are usually much larger than the females. Many of the species possess powers of stridulation.

Species of this group are common in India. The most important, owing to the position it occupies as a serious pest, is probably the beetle *Oryctes rhinoceros* or the rhinoceros or date-palm beetle of which the grub and imago are shown in fig. 143. The grub is about 4 inches in length when full grown, large, stout, yellowish white with a brownish head, powerful jaws, three pairs of legs on the thoracic segments and the posterior ones curved round. The beetle is black, shining, massive, with a prominent horn, which curves backwards on its head; it is owing to the presence of this horn that the insect gets its name. The wing cases are very convex above and there is a large roughly heart-shaped depression on the thorax dorsally. The beetle is an easy one to recognise. This insect inhabits the southern half of the continent, being chiefly confined to those areas in which the date-palm, cocoanut, and palmyra palms flourish. It has been reported as plentiful in the Konkan, Kanara, Salem, Kistna, and Godavery Districts, and is also found in Eastern Bengal and Assam. It is plentiful in Calcutta. The beetle attacks the crown of the tree, boring down into the growing shoot and thus cutting large holes in the young leaves which thus have ragged edges on expanding. When several beetles attack the growing shoot the tree is killed. The eggs are laid in dead or nearly dead trees or in heaps of refuse in the plantation. The grubs on hatching out feed in these localities. It is thus obvious that dirty plantations encourage the pest to increase, whereas a plantation with no dead or dying trees or heaps of refuse in it will be free from it. The grubs of this beetle also feed upon and destroy young Casarina seedlings in the plantations on the East Coast of Madras.

As an example of the curious projections present on these insects the male and female of the beetle *Xylotrupes gideon,* an inhabitant of Assam and Burma, is

* For a fuller account see Departmental Notes, Vol. I, p. 87.



140. *Lachnosterna impressa* : *a*, larva ; *b*, pupa ; *c*, beetle ; *d*, enlarged antenna.
141. *Serica Alcocki* : *a*, beetles feeding on a leaf ; *b*, beetle enlarged.
142. *Lepidiota bimaculata*.
143. The Date-palm or Rhinoceros beetle (*Oryctes rhinoceros*) : *a*, larva ; *b*, beetle.

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figured here (fig. 144 a, b, c.) The beetle rings seedlings of *Poinciana regia* in Burma thus killing them (fig. c.)

The CETONIIDES or rose-chafers are well-known insects owing to the great beauty of their colouration. They are squarish flat beetles, often metallic green or brown in colour, or dull brown or black with bright spots of colour on thorax and elytra (fig. 145). They owe their name of 'rose-chafer to the fact that species are commonly found on rose bushes feeding upon and destroying the flowers. The method of flight of this group is curious: the elytra are joined together down the middle and are merely lifted up as one piece to permit the under wings to be unfolded. The insects are to be found on the wing in brilliant sunlight.

In India the sub-family is represented by numerous species, although little is known of their habits and of those of their larvæ which probably all feed upon roots. *Cetonea maculata* (fig. 145), a bronzy brown beetle with white patches on the sides of the thorax, elytra, and base of the head, is a common species in India and is often found upon rose bushes. *Heterorrhina Hookeri* (fig. 146), a fairly large shining green beetle, is an inhabitant of Assam where it is occasionally to be found very plentifully upon *Acacia catechu* trees in May. Towards the end of May 1906 trees of this species were seen loaded with beetles and were entirely defoliated in the areas adjacent to and between the Sunkos and Reidak rivers near their debouchment from the Bhutan Hills.

Adephaga or *Caraboidea.*

Tarsi five-jointed, antennæ filiform or nearly so. Mouth parts highly developed, with slender projecting mandibles; visible ventral segments of abdomen usually five in number. Active, slim, usually dark-coloured beetles with long, powerful legs and capable of swift movement. Both the beetles and their larvæ are carnivorous. The larvæ are usually dark coloured, with a group of ocelli on each side of the head and with well-developed legs, each having two claws This distinguishes them from all other coleopterous larvæ in which only one claw is present.

FAMILY IV.— *Cicindelidæ* (Tiger-beetles).

Bright coloured beetles, with large eyes and with the clypeus (lower part of front of the head) extending laterally in front of the insertion of the antennæ, the latter being long and straight. The mandibles are large and are set vertically instead of horizontally. The elytra are often brilliantly coloured and spotted.

This family includes some of the most active and most carnivorous of the beetles. They feed upon insects of all kinds. The larvæ live in burrows in the ground where they lie in wait for their prey. A species named *Cicindela punctata* (fig. 147) has been reported as destructive to the rice sapper, *Leptocorisa acuta*, a destructive pest in the rice-fields. Investigation will doubtless show that species exist of use in keeping down forest pests. Although a certain number of forest-living *Cicindelas* have been collected, practically nothing is at present known on the subject of the particular species or groups of insects they feed upon, nor as to whether they confine themselves to certain species or not. Fig. 148 shows the large long-legged *Cicindela octonotata* to be found plentifully on the stony riverbeds of the Sankos, Reidak, and other rivers in Assam near their debouchment from the Bhutan Hills.

FAMILY V.—*Carabidæ* (Ground-beetles).

These beetles resemble the *Cicindelidæ*, but the mandibles are set horizontally. They are usually blue or black in colour and are carnivorous in their habits. These beetles can be found in the forest in the humus and top soil, and in decaying wood and stumps. They are very active and run rapidly

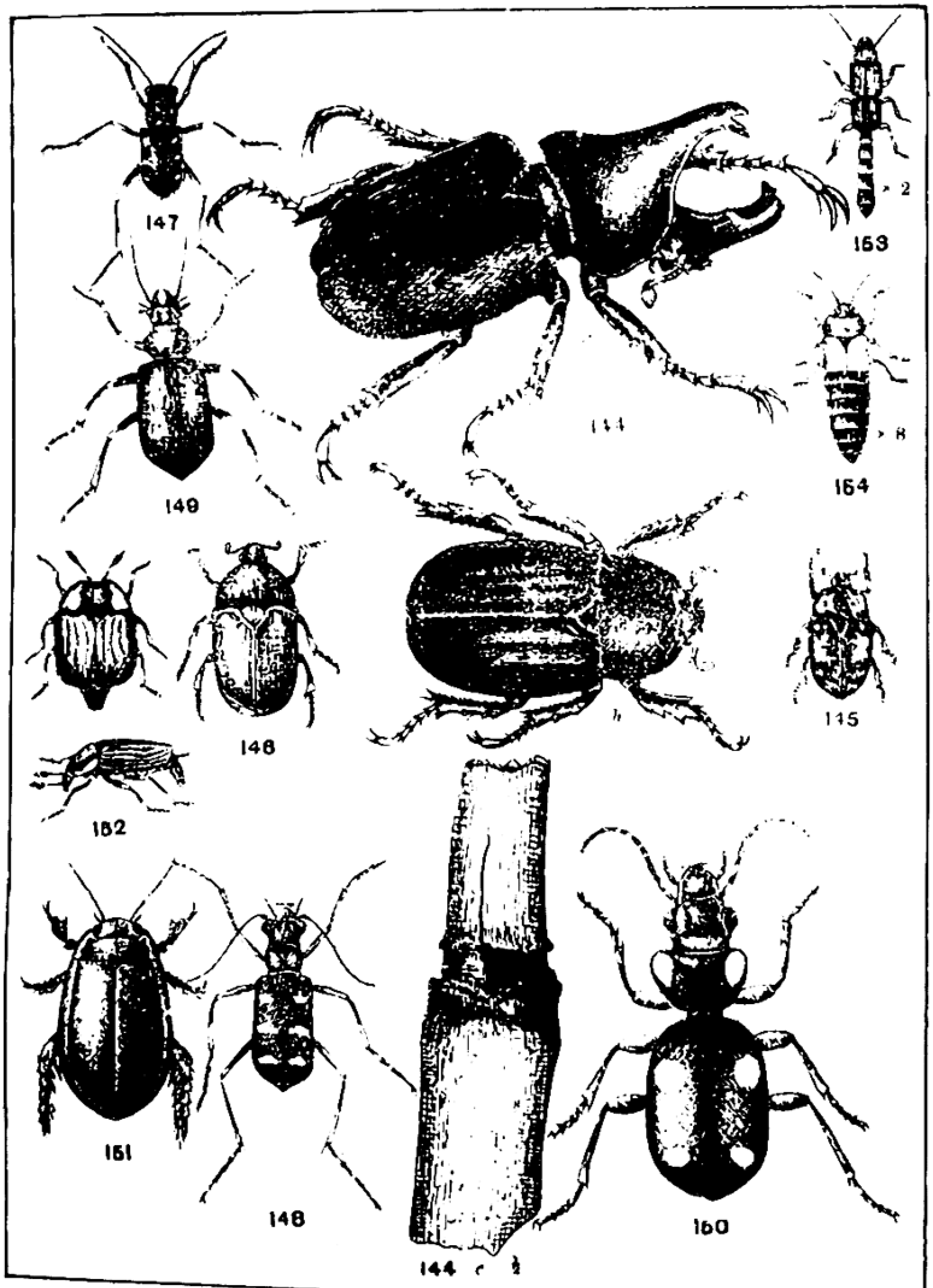
A species named *Calosoma orientale* (fig. 149) attacks and preys upon the young of the locust, *Acridium peregrinum*, destroying them in large numbers. Several othe species are very common in India. The writer has recorded that a large Carabid beetle, *Anthia sexguttata* (fig. 150), with cream-coloured blotches on its elytra, feeds on the larvæ of the hawk moth *Pseudosphinix discistriga* which defoliate the teak in Berar during the rains.

NOTE.—The water beetles, *Dytiscidæ*, and the Whirligigs, *Gyrinidæ*, seen swimming in circles in the sunshine on the surface of pools and streams, belong to this series, but are unimportant. Fig. 151 shows the predaceous water beetle *Cybister limbata* common in Bengal.

Clavicornia.

Tarsi usually five-jointed. Antennæ thicker at the tip or knobbed. All the parts of the insects in this group may vary, exceptions being numerous.

Some of the insects of this series are kept by ants in their nests. Many flat Clavicorns feed under bark on the sap of the tree. A species feeds in this way under the bark of sál trees and another is to be found amongst the bark-boring beetles under the bark of blue pine (*Pinus excelsa*). These beetles should not be confused with the true bark-borers. Some feed upon decaying bark whilst others again are carnivorous.



144. *Xylotrupes gideon*, *a*, *b*, ♂ and ♀ beetles; *c*, portion of a *Poinciana regia* seedling ringed by the beetle.
145. *Cetonia maculata.*
146. *Heterorrhina hookeri.*
147. *Cicindela punctata.*
148. *Cicindela octonotata.*
149. *Calasoma orientale.*
150. *Anthia sexguttata.*
151. *Cybister limbata.*
152. *Silpha tetraspilota.*
153. *Staphylina sp.*
154. *Staphylina ? sp.*

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FAMILY VI *Silphidæ* (Carrion-beetles)

Antennæ clavate or at least flattened at the tips In some forms the elytra cover the whole of the abdomen; in others its tip is left uncovered These beetles are as a rule carrion-feeders. The genus *Silpha* has slightly clavate antennæ elytra covering the whole of the abdomen, and the body of a flat, oval form. The larvæ are broad and flattened, and find their own food, *i.e.*, it is not stored up for them by the parent beetle. Both larvæ and adults feed on dead animals. The Burying-beetles (*Necrophorus*) have markedly clavate antennæ, elongate bodies, and short elytra, usually coloured in red and black bands, leaving the hinder end of the body uncovered. Several generally unite to bury small mammalia, etc., removing the earth below the carcase, in which they lay their eggs. The larvæ are pale and large, possessing legs and eyes; they feed upon the carrion buried by their parents. These beetles may be seen in the forest at work in this way Fig. 152 shows *Silpha tetraspilota.*

FAMILY VII.—*Staphylinidæ* (Rove-beetles)

These beetles are distinguished by the small size of the elytra; the larger portion of the abdomen, which is very moveable, is not covered by them but has a deposit of a thick layer of chitin on its dorsal surface. The hind wings are folded under the elytra. The body is elongate or ovoid and antennæ filiform. Some of these beetles run with great activity The adult generally lives upon decaying plant and animal substances, often feeding upon small insects. The larvæ are like those of the Carabidæ, but have only a single claw on each foot. They have two-jointed cerci at the end of their bodies. They feed either like the adults or are predaceous. Numerous mature beetle forms, believed to be predaceous, have recently been found by the writer in the tunnels of bark and wood-boring Scolytidæ in deodar, spruce and blue pine, etc., and it is probable that the family will be found to be of considerable (forest importance in this respect. Fig. 153 shows *Staphylina* sp. predaceous upon Polygraphus and fig. 154 *Staphylina* sp. predaceous upon Scolytus.

FAMILY VIII.—*Histeridæ*.

Compact beetles, with a hard integument, often shining; short, ben antennæ ending in a compact club; the elytra leave two segments

of the body exposed. Abdomen with five visible ventral segments; hind coxæ are widely separated. The beetles are usually black in colour.

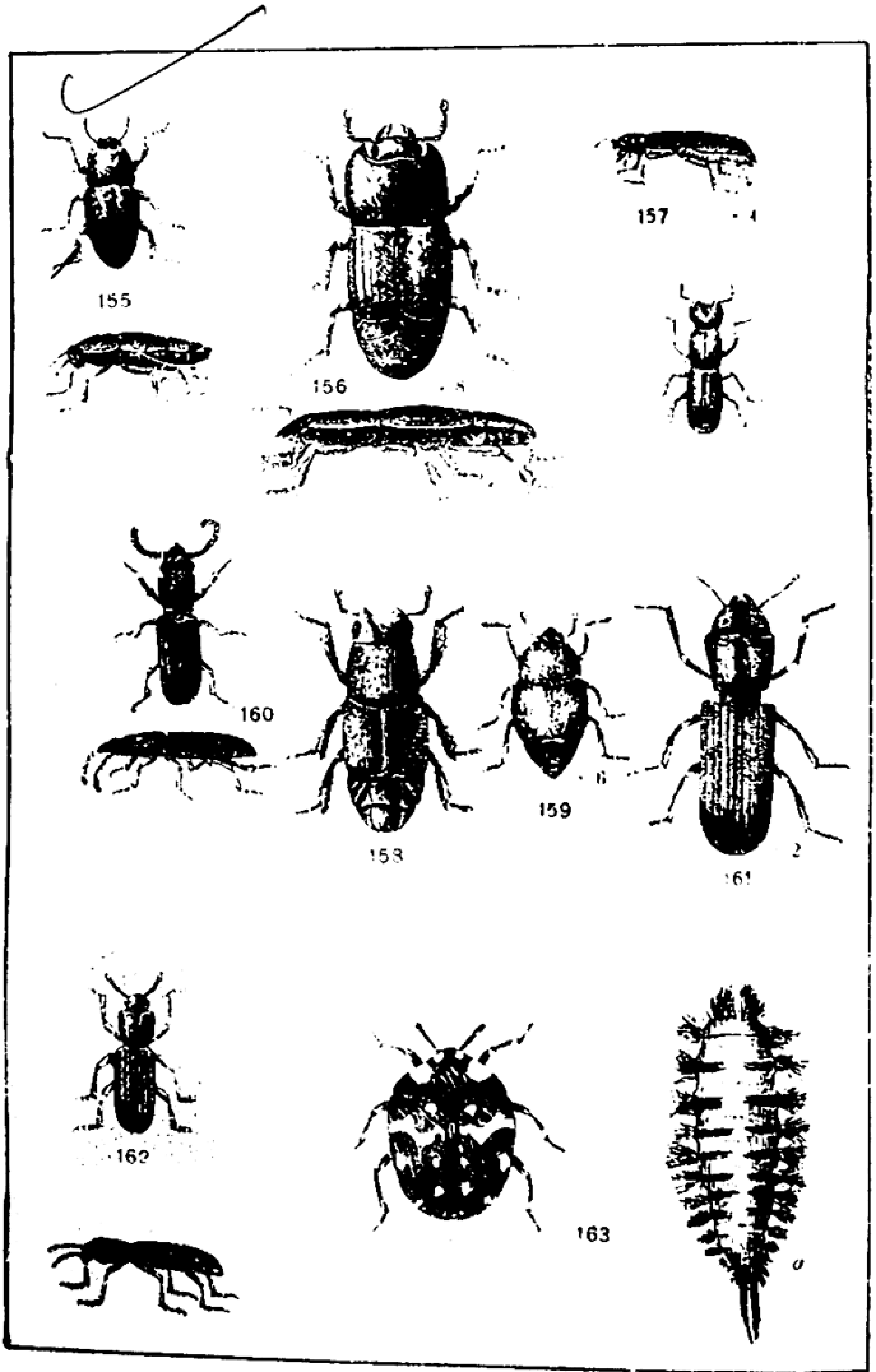
The members of this family are common in dung, in carcases, decaying fungi, etc., and some live under the bark in the tunnels of bark-boring insects, these being often very flat insects. Some are small cylinders, constructed for entering the burrows of insects boring into wood. It has been for some time believed, and the writer has been able to verify the fact in several instances quoted below, that the species of this family living under bark and in wood are predaceous and feed upon the larvæ and adults of boring beetles. Some live in ants' nests, probably devouring the larvæ. A few species live in company with Termites.

From observations made during the last few years it has been shown that members of this family play an important part in keeping down the numbers of wood-boring and bark-boring beetles of the families *Bostrichidæ* and *Scolytidæ*. Species of Histerids (*Teretriosoma cristatum, intrusum, Stebbingii*) (*see* fig. 155) have been found in the tunnels of the Bostrichid wood-borers, *Sinoxylon crassum* and *S. anale*, preying upon their larvæ. These latter riddle the wood of *Dalbergia Sissoo* in the Changa Manga plantation (see p. 89) These histerids are small, flat, shining, black beetles.

Platysoma dufali (fig. 156), a beetle resembling the above, is predaceous upon the bark-borer *Tomicus* sp. in blue pine and another species of the same genus on the bark-borers *Scolytus major* and *S. minor* in deodar and *Polygraphus minor* in the blue pine. *Platysoma* sp and *Paromalus* sp. are also predaceous upon the wood-borers *Hylastes* sp. and *Rhyncholos* sp. *Niponius* is a genus of cylindrical beetles, a species of which, *N. canalicollis* (fig. 157), follows the *Scolytus Polygraphus, Hylastes* and *Rhyncholus* beetles into their tunnels in blue pine and preys upon them in the North-West Himalayas, whilst *N. Andrewesi* (fig. 158), a beetle of similar shape, but with a red abdomen, does the same in the case of the bark-borers *Sphærotrypes siwalikensis* and *S. coimbatorensis* which respectively infest the sâl tree in the Siwaliks and the Anogeissus in the Coimbatore forests.

FAMILY IX.—*Nitidulidæ.*

Antennæ have a three-jointed club; all the coxæ are separated and each has an external prolongation; tarsi five jointed, the fourth joint being smaller than any of the others; abdomen with five visible segments. The habits of these beetles are very varied, some live in flowers, others under the bark on the sap of trees, others again in carcases. One larva causes much loss by living in the flowers of the



155. *Teretriosoma stebbingi* (*mag*)
156. *Platysoma dufali.*
157. *Niponius canalicollis*
158. *Niponius Andrewesi* (*mag.*)
159. *Carpophilus flavipes.*
160. *Hectarthron brevifossum.*
161. *Trogositita rhyzophagoides.*
162. *Bothrides sp* (*mag.*)
163. *Dermestes vulpinus.* *a*, larva ; *b*. beetle (*mag*)

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mustard (rape) and prevents the seed forming. It pupates in the ground. Another one feeds upon turnips. Many Indian forms will doubtless be found feeding upon the sap of trees on newly cut stumps, etc., and should not be confused with bark and wood-borers.

Carpophilus flavipes (fig. 159) and other species of minute flat brown beetles are to be found commonly feeding at sap beneath the bark of felled sal trees in the Dun. Species have also been found beneath the bark of the Indian spruce and blue pine in the Himalayas.

FAMILY X.—*Trogositidæ.*

These beetles resemble those of the above family. Some are of fair size. The commoner ones found in India are elongate, straight-sided, black beetles with large well-marked antennæ, mandibles which gradually increase in thickness upwards, and deeply longitudinally ridged (striate) elytra. Some of the members of the family are predaceous both in the adult and in the larval stages.

Hectarthrum brevifossum (fig. 160) is a beetle, black in colour, a little over half an inch in length, with the elytra broadly striate. It has been bred out of a block of *Shorea assamica* wood where it was thought to be predaceous upon a cerambyx beetle or its grubs. The writer bred it out of a *Terminalia tomentosa* pole which was badly infested with Bostrichid (*Sinoxylon*, *Xylopertha*, and *Lyctus*) borers. *Trogositita rhysrophagoides* (fig. 161) resembles the last, but is smaller. It was also bred out of the Terminalia post. Both larva and beetle are eminently predaceous and were feeding upon the bostrichid larvæ and beetles.

Species of this family have also been found in Burma beneath the bark of *Nauclea sessilifolia* and Pyinkado, predaceous upon several scolytid and platypid wood and bark-borers.

FAMILY XI.—*Colydiidæ*

Antennæ have a terminal club, the tarsi are four-jointed ; the front and middle coxæ are rounded and sunk ; visible abdominal segments five. These beetles have often a highly sculptured squarish thorax and longitudinally striate elytra. The commoner Indian species found beneath the bark of trees are brown in colour. The tree-living forms are very active, both larvæ and beetles living upon the larvæ of wood and bark boring insects.

A species, *Bothrides* sp., (fig. 162) has been found feeding upon *Sinoxylon anale* in Sissu wood.

The biscuit weevil (fig. 171) belongs to the closely allied family *Cucujidae*. It attacks and lays its eggs in biscuits and also in books in India, its food being exceedingly varied.

FAMILY XII.—*Dermestidæ.*

Small beetles, with deflexed heads and clavate antennæ: the surface of the body is covered over with small close-set hairs. Both beetles and larvæ feed upon dead animal substances, such as skins, etc., and are often very injurious to the latter. The larvæ and beetles issuing from the skin of a newly shot animal that has been left untended for a few days are Dermestidæ and will not unlikely be the common species *Dermestes vulpninus* (fig. 163a-c). When full fed the larvæ hide themselves away, some times burrowing into hard wood. They do damage in museums and to stored hide goods, boots, etc.*

Serricornia.

Antennæ usually serrate along their inner edge. Other characters may be variable.

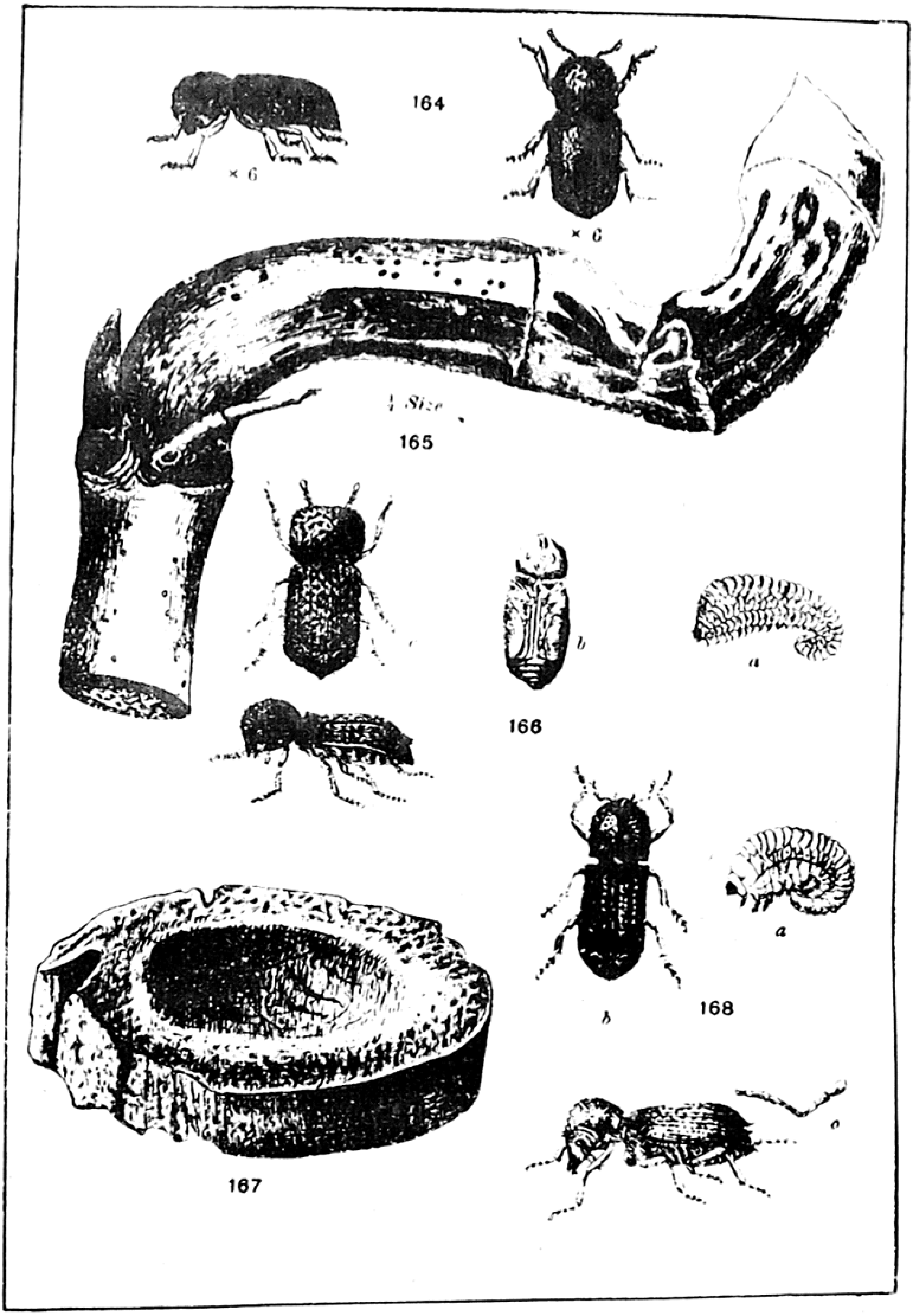
FAMILY XIII.—*Bostrichidæ* (Bark and Wood-borers).

Usually small brown or black beetles with straight antennæ which are often lamellate at the top (fig. 168, c.). The prothorax is often furnished in front with protuberances and the elytra behind may be truncate and furnished with small spikes. Tarsi five-jointed but the first joint is very short; front coxæ are prominent and contiguous and extend very little transversely; five ventral abdominal segments are visible.

The larvæ are white, have three pairs of legs and have the posterior parts of the body incurved (*cf.* fig. 48, a). The pupa has the general appearance of the beetle but is white and the antennæ, legs, and immature wings are pressed against the chest and sides, fig. 48, b.

These beetles tunnel into dying and dry wood, in which they lay their eggs; the larvæ on hatching out feed upon the wood. The insects are at times present in such numbers that they entirely riddle and destroy the timber they infest. One or two members of the family have already proved to have a wide range in India, such, for instance, as several species of *Dinoderus* in bamboos, and *Sinoxylon* in the wood of broad-leaved trees.

* To protect saddlery, etc., when stored away from such pests, the articles should be placed in tin-lined boxes, and plentifully besprinkled with napthaline before the case is sealed up.



164. *Dinoderus pilifrons.* Side and dorsal views of beetle.
165. A piece of bamboo riddled by the insect.
166. *Sinoxylon crassum.* *a*, larva ; *b*, pupa ; *c*, beetle.
167. Section of a Sissu fuel billet infested by this beetle.
168. *Heterobostrichus æqualis.* *a*, larva ; *b*, beetle ; *c*, enlarged antenna of beetle.

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Life-histories of the Dinoderus or Bamboo beetle-borers.

The two common bamboo-borers in India are *Dinoderus pilifrons* and *D. minutus*, the first attacking bamboos in the northern half of the continent, and the second in the southern. They are small brownish beetles about one-sixth inch long and cylindrical in shape. The larvæ are yellowish white, corrugated and curved. Neither of these beetles apparently attack green growing bamboos. As soon as they are cut, however, or very shortly after, the beetles make their appearance (the species attacking varying according to the locality) and tunnel into the wood of the wall of the bamboo (or right down into the wood structure if solid) and lay their eggs there; in the case of *D. minutus* the number laid is about twenty. About a month is spent as a larva feeding in the woody structure and two weeks as a pupa, a generation taking about six weeks to two months to pass through. *D. pilifrons* (fig. 164) passes through four and *minutus* about six generations in the year. They hibernate as eggs or larvæ in the winter. These insects cause an immense loss yearly in India attacking all bamboo structures and entirely riddling them. Their presence is easily discernible owing to the appearance of the "shot holes" in the bamboo and to the piles of sawdust which they eject from the holes. Soaking the bamboo in Rangoon oil for forty-eight hours or so is a good preventive.* Fig. 43, *a, b, c,* shows *D. minutus* and fig. 165 pieces of attacked bamboos.†

Dinoderus distinctus attacks the twigs of the mango tree in the Dun plateau, laying her eggs in them in April. The larvæ on hatching out feed in the wood and kill the twig.‡

Life-history of *Sinoxylon crassum*.

Sinoxylon crassum and *S. anale*, both of which have a wide distribution in the country, do considerable damage to wood stacks in the Changa Manga plantation, and these beetles will always have to be reckoned with in fuel and wood depôts. At Changa Manga this beetle makes its first appearance in the year about the beginning of April and burrows into the sissu fuel stacks, consisting of the wood cut over between the previous November to March; this wood is collected and stacked upon the adjacent compartment lines to allow the fuel to dry. Eggs are laid by the beetles which hatch out into small white grubs within a few days. The larvæ feed entirely in the wood and take about six weeks to become beetles. These beetles emerge from the wood in July and at once lay the eggs of another generation in suitable wood, these eggs giving rise to a second generation of beetles in September-October. These beetles hibernate as such in the wood through the winter. In warmer parts of the country there are probably

* *Vide* my Note on the Preservation of Bamboos from the attacks of the Bamboo beetle or Shot-borer. *Indian Forester*. XXIX, Appendix Series I. *Ibid*, XXXI, p. 249.

† *Protection*.—As soon as felled bamboos—and this applies equally to poles—should be either kept under water for a few weeks or smoked so as to dry them quickly.

‡ On the Bostrichidæ of the Indian Region.—Indian Museum Notes, VI, pp 21—24.

at least three generations of this pest in the year. *S. anale* will attack drier wood than its companion and has probably a greater number of life cycles in the year. Fig. 166, *a*, *b*, *c*, *d* shows the larva, pupa, and beetle of *Sinoxylon crassum* and fig. 167 a piece of attacked wood.* S. crassum also tunnels into the wood of Terminalia tomentosa† and into sal† twigs in the Dun.‡

Heterobostrichus æqualis (fig 168) bores into and riddles the wood of *Bombax malabaricum* in Malabar. As this wood is used for tea boxes by tea planters, the beetle causes considerable damage (*vide* fig. 169). *Bostrichopsis parallela* (fig. 170) tunnels into and riddles the bamboo Dendrocalamus strictus in the Central Provinces.

FAMILY XIV.—*Ptinidæ*.

Tarsi five-jointed, the first joint not reduced in size, often longer than the second; front and middle coxæ small, not transversely extended; five visible ventral segments. Here also, as in the last family, the thorax is hood-like and often covered with projections like a rasp and there are several spines on the posterior end of the body, which may be truncate. The head with the antennæ and mouth parts can be stowed away in a cavity in the chest. In fact the skeleton is at times so adapted that all the appendages, such as the head, antennæ and legs, fit into recesses so that, in repose, the insect looks like a seed. In this family both the grubs and the beetles bore a cylindrical hole corresponding to the maximum diameter of the beetle's body.

Two sub-families, the Ptinides and the Anobiides, are included here. The Ptinides are sometimes destructive to dried animal matter, and attack museum specimens. The Anobiides bore into wood and apparently spend a very short time in the adult stage. Their larvæ resemble those of the last family.

The cheroot weevil,§ *Lasioderma testaceum* attacks cigars of all kinds in India, the insect running through a large number of generations in the year. It also infests pipe-tobacco (*see* fig. 172).

FAMILY XV—*Malacodermidæ*.

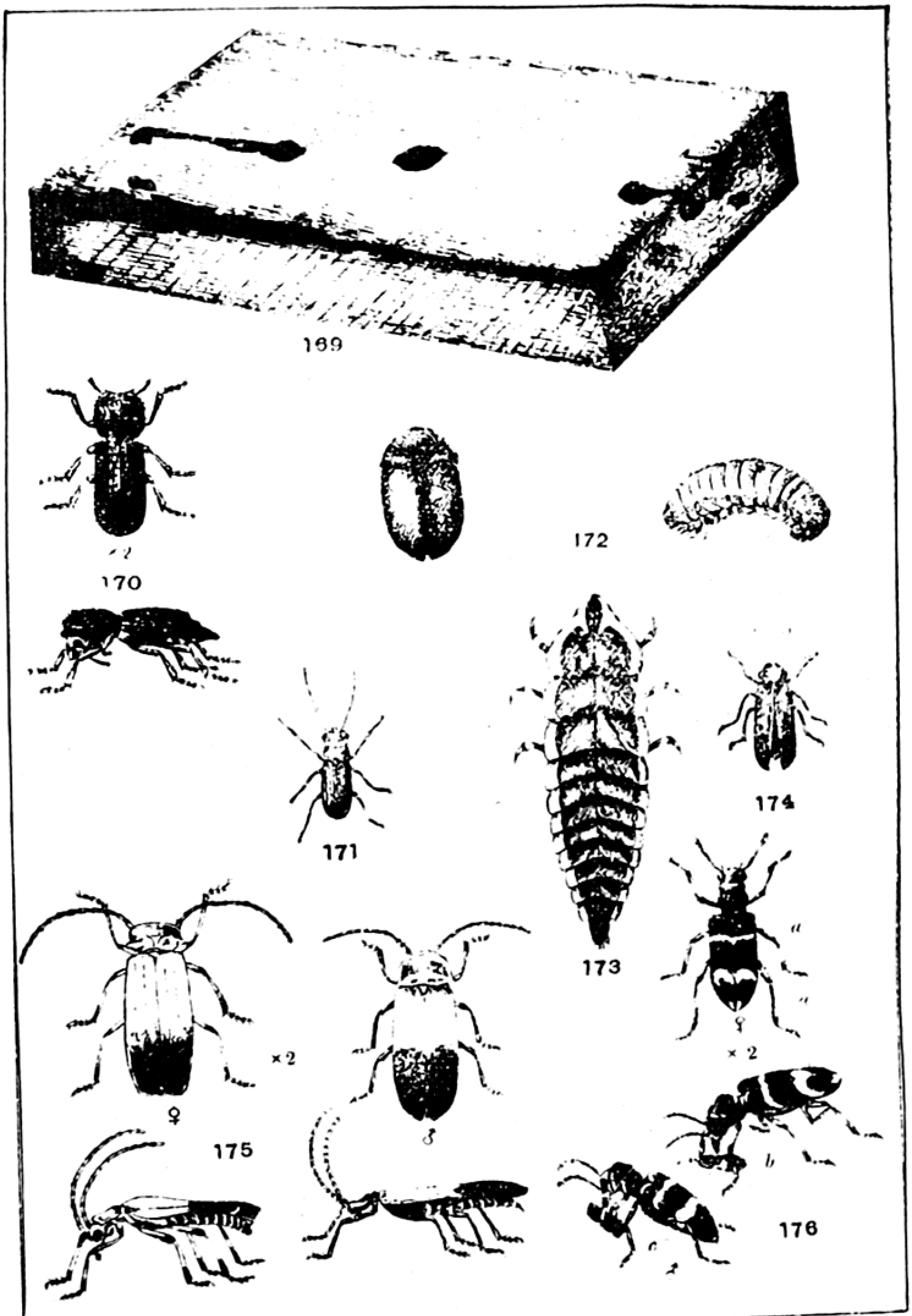
Beetles with very soft bodies and elytra; the prothorax is generally broad and shield-shaped and the head may be hidden beneath

* See Departmental Notes on Insects that affect Forestry, Vol. I, pp. 12—18.

† *Vide* 'Insect Life in a Terminalia Post' in the *Indian Forester*, Vol. XXVIII, No. 8.

‡ *Vide* Departmental Notes on Insects that affect Forestry, Vol. I, p. 164.

§ To get rid of the cheroot weevil from a cigar store the only plan is to burn all infected stock and thoroughly cleanse out godowns.



169. Piece of *Bombax malabaricum* wood attacked by the beetle *Heterobostrichus æqualis*.
170. *Bostrichopsis parallela*.
171. The Biscuit beetle (*Lœmophloeus pusillus*).
172. *Lasioderma testaceum* (the Cheroot Beetle).
173. Glow-worm.
174. Fire-fly (*Luciola*).
175. *Plateros dispallens* (male and female).
176. *Thanasimus himalayensis*. *b*, *c*, beetle devouring a Scolytus bark-boring beetle.

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it. The elytra are soft and leathery and are not rigidly attached to the body. They do not meet in a hard and fast suture in the middle and often leave several body segments exposed. Eyes are large. Seven visible ventral segments of the abdomen are present. The females are often wingless.

The family includes the Lampyrides or Glow-worms and the Fire-flies (Luciola). The larvæ are supposed to be carnivorous, but little is known about them in India. The phosphorescent apparatus is placed ventrally at the posterior end of the abdomen. In the glow-worms the female is wingless and her light is much more powerful than that of the male and may serve to attract him. In the fire-flies both males and females have wings and the light is more powerful in the male than in the female. Fig. 173 shows a glow-worm common in the North-West Himalayas and fig. 174 the common fire-fly of this country.

Plateros dispallens (fig. 175), a slender black insect with the basal half of the elytra orange yellow, is common on Teak leaves in the Central Provinces in July and August.

FAMILY XVI.—*Cleridæ*.

This family contains beetles of varied form and colour. The antennæ are usually more or less club-shaped at the tip, and not at all serrate. The tarsi are five-jointed, but the basal joint of the hind tarsus is very short, and the apices of joints two and four are usually prolonged into membranous flaps. The insects have, in some instances, a superficial resemblance to small longicorn beetles (*Cerambycidæ*). The *Cleridæ* are exceedingly predaceous and their larvæ are very active, being specially fond of wood and bark-boring grubs.

The family is of the greatest service to the forester in India owing to their predaceous habits. A newly discovered species, *Thanasimus himalayensis*, is predaceous, both in its larval and imago stages, upon various wood and bark-boring beetles in the coniferous forests of the North-West Himalayas. The following is a summary of what is at present known upon the life-history of this insect * :—

Life-history of *Thanasimus himalayensis*.

The larva is an elongate, flat, pink coloured grub with a brownish head, well marked black mandibles, and the last segment of the body terminating in two small black processes or

* Dep. Notes Vol. I. pp. 213-218; J.A.S.B. LXXII, Pt. II. 3. (1903)

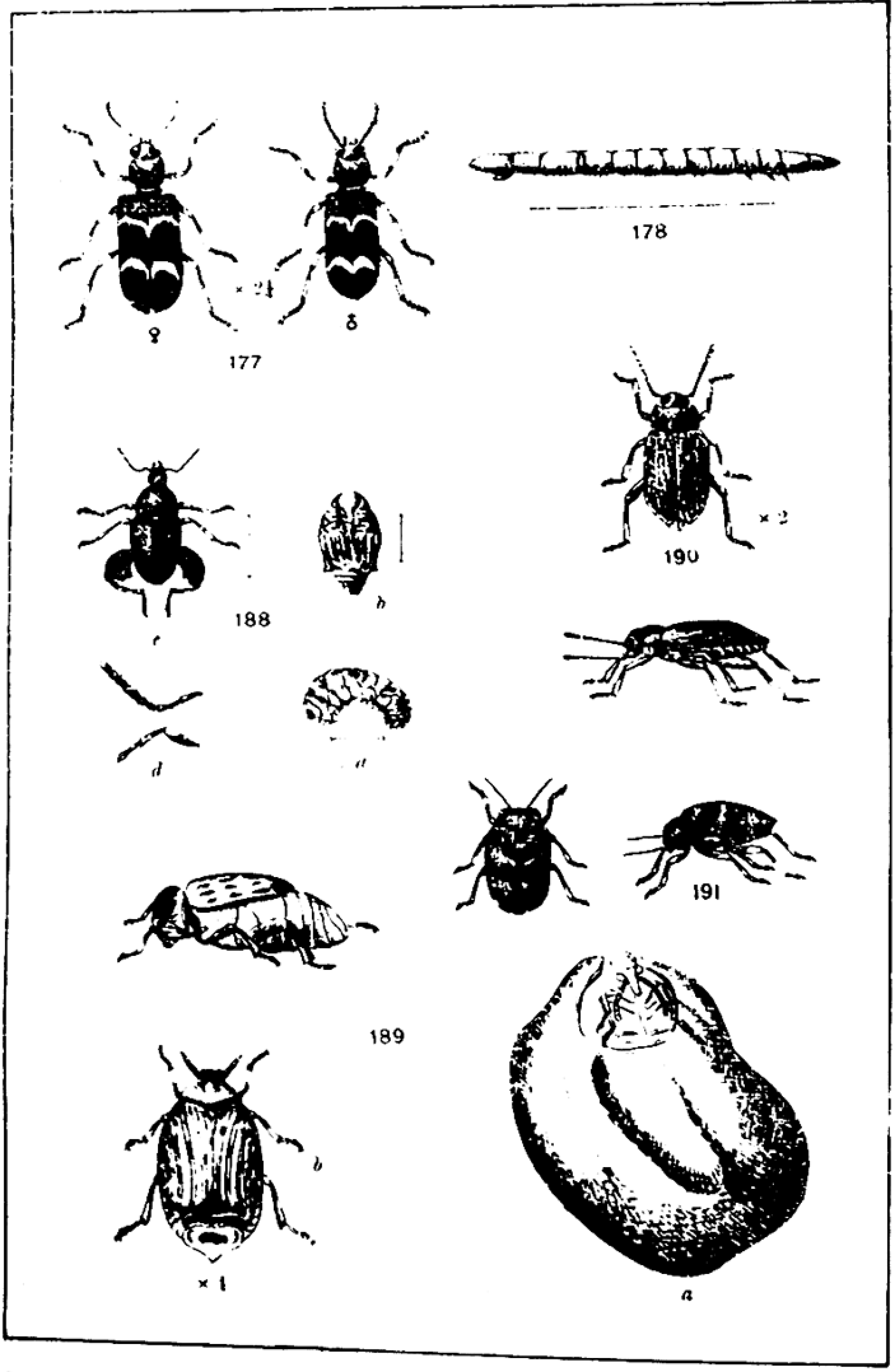
points. The beetle (fig. 176) is an active, bright coloured insect, with an ant-like black head and prothorax, whilst the elytra are red at their bases and black anteriorly, the black being crossed by two white wavy bands. The abdomen beneath is bright vermilion in colour. The insect is half an inch in length. The beetles are to be found plentifully in June and July either on the wing or running actively about on the bark of coniferous trees (also oaks to a certain extent), such as deodar, spruce, blue pine, etc., searching for bark-beetles. As these latter emerge from and settle upon the bark of the trees, the clerids seize and devour them (fig. 176), only the harder portions of the chitinous exterior being rejected. Inside the tree, in the galleries made by the bark-boring beetles and their larvæ in the cambiun and sapwood, are to be found the pink larvæ of this clerid engaged in feeding upon the larvæ of the bark-borers. It is probable that the predaceous beetle lays its eggs in the entrance holes of the boring beetles, and the young grubs on hatching out find their way down the entrance tunnel into the egg and larval galleries of the bark-beetle. Larvæ of various sizes have been found in the tunnels between May and October and it is not improbable that there are several life cycles in the year overlapping each other and that consequently the beetle is to be found on the wing in the forest during these months. The insect is polygamous and excessively voracious. The writer has observed it to feed upon one or more species of the genera *Scolytus, Polygraphus, Pityogenes, Tomicus, Hylastes, Rhyncholus, Diapus,* and *Platypus,* all bark or wood-boring members of the families *Scolytidæ* and *Plapypodæ.* These beetles will be dealt with later on in this work.

The importance of this Clerid is evident when it is remembered that *Clerus formicarius* is known to be of the greatest value in keeping down bark-beetles in European continental forests. So great is the value attached to this beetle that in 1892 a specialist was deputed from America to import it into that country in the hopes of bringing down to normal proportions some devastating bark-boring beetle attacks.

Another species of Thanasimus (fig. 177) is predaceous upon the bamboo borer *Dinoderus minutus* in Calcutta. This beetle follows the shot-borers into their tunnels in the bamboo.

FAMILY XVII.—*Elateridæ* (Click beetles).

Small beetles with a much sunk head and a square prothorax which finishes behind in two points. Legs short, and very rigid The prothorax is prolonged on the under side as a spine which fits into a pit in the meso-thorax. This arrangement is to enable the insect to jump up into the air, when on its back, and so turn over again. When the prothorax is raised the spine is supported against the edge of the depression, and on its being allowed suddenly to



177. *Thanasimus sp.*

178. *A Wire-worm.*

188. *Caryoborus gonagra.* The Tamarind Bruchid *a*, larva; *b*, pupa; *c*, beetle; *d*, enlarged antenna and leg

189. *Caryoborus sp.* The Albizzia seed beetle; A, albizzia seed with beetle emerging; *b*, side and dorsal view of beetle.

190. *Boswellia Halticides.*

191. *Haltica (?) sp.*

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shoot back into the pit, the insect strikes the ground with considerable force and is thus jerked up into the air. The click they make in this movement gives them their name of click-beetles. The grubs are called 'wire-worms' (fig. 178). They are long, thin and hard, and consist of twelve segments, with a flattened horny head and three pairs of legs. The head is dark brown and the twelve remaining segments yellow to yellowish-brown. They can be distinguished from Millipedes (p. 168) in possessing only three pairs of legs, whereas the latter have two pairs of legs on each segment.

Some members of this family are quite harmless, since they only devour decaying vegetable matter either in humus or in the rotting substance of dying trees where they are often to be found. Many elaterid larvæ, however, are destructive as root-feeders, and it is in the forest nursery or in areas sown and planted up in patches where trouble may be expected from these pests. The grubs are very active and destroy much more than they actually devour, moving from plant to plant and cutting through the roots below the surface of the soil. In this way they may destroy whole lines of young plants in a nursery. The larvæ live for several years in the ground and probably feed during most of the time, growing to full size very quickly and spending the rest of the time as a full-grown grub. Though constituting a serious pest in European forests very little is known as to their operations in India. Recently, however, wire-worms (fig 178) have been found attacking the roots of young deodar plants sown in patches and those of a dying young sweet chestnut which had been imported from England, both cases occurring in the North-West Himalayan forests. An inspection of the roots showed that the dying condition of the young plants was probably due to the elater grubs. These grubs and the damage they are capable of doing should be borne in mind when seedlings are seen to be dying in the nursery without any visible cause apparent above ground. Fig. 179 shows a large species of *Elater* taken from the timber of the trunk of a large *Dalbergia* sp. tree in Burma.

FAMILY XVIII.—*Buprestidæ.*

These beetles resemble the Elateridæ, but they have not the jumping apparatus, the pro-and meso-thorax being firmly united. The beetles are often very brilliantly coloured with metallic colours. The lower wings are usually the same size as the elytra; the antennæ are serrate, some of the basal joints being usually cylindrical. The larvæ are soft, and white, with a horny head which is retractile, and an enormous prothoracic segment (fig. 181, a). They have no legs. The segments of the abdomen are much narrower than the prothorax and by this character these larvæ can be always distinguished from

longicorn ones which they otherwise closely resemble. They usually live upon wood and do damage by attacking newly-felled or sickly trees, in which they bore large, winding, flat galleries. Healthy trees are generally safe from these attacks, but the moment a tree becomes sickly and weakened from any cause buprestid beetles at once lay their eggs in the bark and the larvæ bore into the wood. These insects are numerous in India, but little information has as yet been collected on their life-histories. Most trees will be found to be subject to their attacks.

Catoxantha bicolor is a large brilliant metallic green or blue buprestid with a yellow patch about the centre of each elytra. Its grub feeds in the cambium and sap layer of pyinkadu and other trees. This insect is to be found as far west as the Buxar Duars and stretches down into Siam. Fig. 180 shows this buprestid. Mature beetles have been taken in May-June.

The grubs of *Capnodis* sp. tunnel in chenar and poplar trees in Quetta, remaining chiefly in the sap wood and bast layer. Full-grown grubs have been taken from the trees in October. The beetles are very numerous in May-June and also in October-November. They probably issue irregularly throughout the summer and autumn months. Fig. 181 a, b, show the larva and beetle.

A small buprestid named *Chrysobothris sexnotata* (fig. 182) is to be found commonly in the branches of the sál, it taking about a year to pass through one life cycle. The eggs are laid in the bark and the larva at first lives in the bast layer and then bores into the sap wood. Dying branches of trees are at times full of these beetles as are also the tops of felled trees.

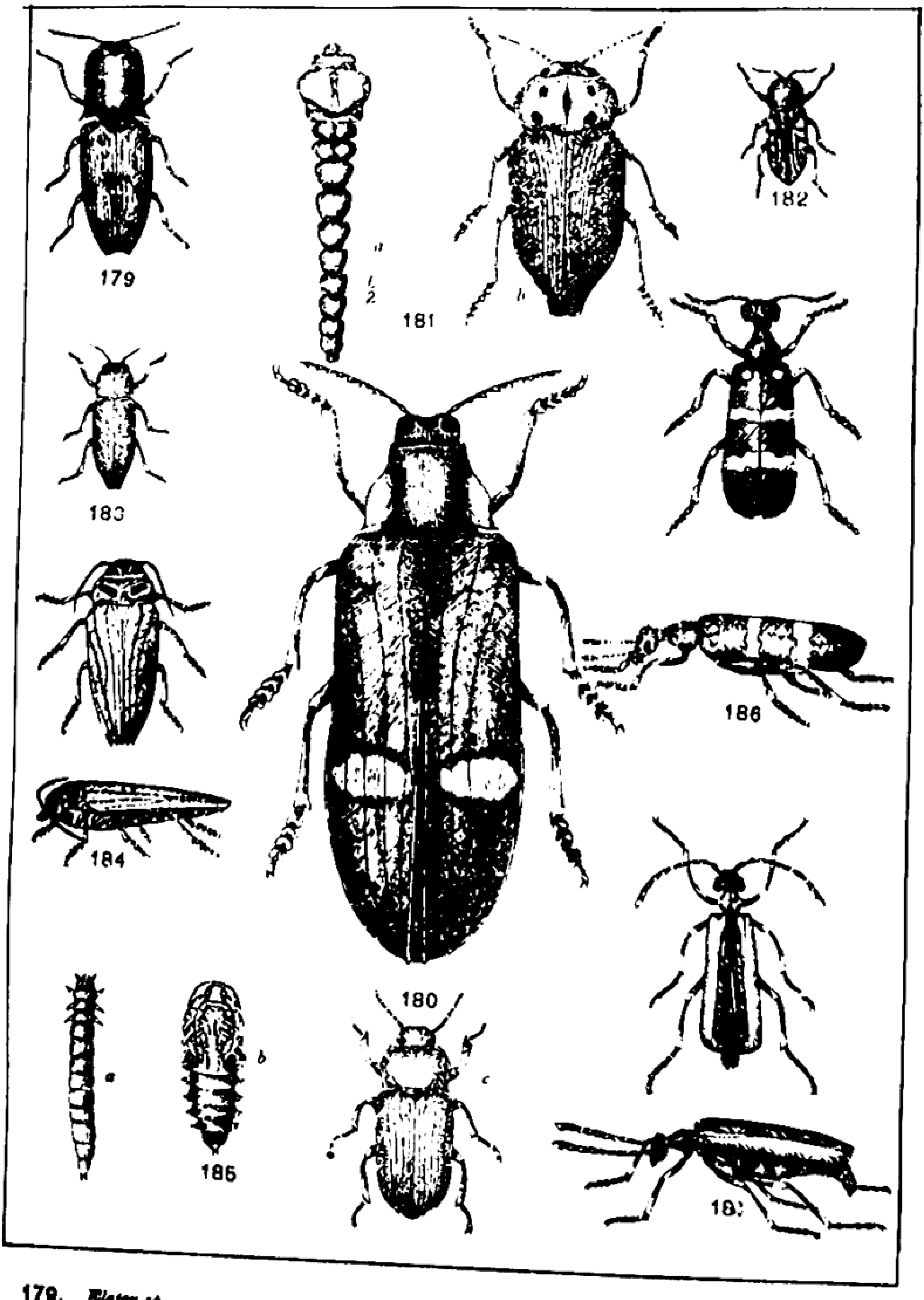
Psiloptera fastuosa (fig 183), is a buprestid beetle which has been reported as attacking teak wood at Nilambar, Malabar, whilst *Belionota scintillans* (fig. 184), a handsome beetle, lives in the Khair in the Siwaliks. *

The larvæ of a yet undescribed species are invariably found beneath the bark of deodar, spruce, and blue pine trees infested with scolytid beetles, the buprestids coming in later than their companions.

Heteromera.

The first and second pair of legs have five-jointed tarsi, the third pair having four only.

* *Vide* Injurious Insects of Indian Forests, pp. 42-45.



179. *Elater sp.*
180. *Catoxantha bicolor.*
181. *Capnodis milliaris* : *a*, larva ; *b*, beetle
182. *Chrysobothris sexnotata.*
183. *Psiloptera fastuosa.*
184. *Belionota scintillans.*
185. Sal Tenebrionid beetle : *a*, larva ; *b*, nymph ; *c*, beetle.
186. *Mylabris pustulata.*
187. *Cantharis antennalis.*

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FAMILY XIX.—*Tenebrionidæ.*

Very common beetles in India. Owing to their dark colouring and shape they have a general resemblance to Carabidæ, from which they can of course be distinguished by the tarsal joints. The lower pair of wings is often absent and the elytra are often soldered together. The larvæ are elongate and cylindrical and are hard, and have six legs, being not unlike elaterid grubs. Their food is mostly vegetable matter, including grain and flour.

They are often to be found beneath the bark of dying or dead trees; it is uncertain, however, at present whether the larvæ or beetles, or both, feed upon the dying bast and sap wood or upon the decayed parts, or whether the grubs themselves are predaceous. Fig. 185 a, b, c, shows the larva, pupa, and imago of a tenebrionid common in sál trees in Assam. Undetermined species have also been bred from dead spruce and blue pine trees in the North-West Himalayas. Some years ago a species was reported as tunnelling into sandal wood in Mysore, but the specimens were in bad condition, and could not be identified.

FAMILY XX.—*Cantharidæ* (Blister Beetles, Oil-Beetles).

Head with an abrupt neck; hind-wings usually present, elytra short and do not fit well together, but overlap; each claw of the feet has a long appendage beneath it. The beetles have a very soft integument and they secrete irritating secretions which raise blisters on the skin. Some of the insects are wingless. The Cantharidæ feed upon flowers and leaves and frequently do a little damage in this way.

A common one in India (*Mylabris*) has the elytra banded with yellow and black stripes. This insect is shown in fig. 186. It is often very plentiful in Dehra in July and August, consuming the fruits of a species of Artocarpus by stripping the pericarp off and also feeding upon the petals of roses, hibiscus, and other flowering plants. When numerous it causes considerable damage in the flower garden at this time of the year. Several others are equally typically marked. *Cantharis autennalis*, fig. 187, is to be found at times flying in flights or swarms in the North-West Himalayas in July. It is a brilliant metallic green handsome beetle, and feeds on species of *Lonicera.*

Tetramera.

Four tarsal joints are present on all the feet. Several of the families of this group contain serious pests, both to forests and agriculture.

The group is divided into the two Series Phytophaga and Rhynchophora.

Phytophaga.

The head does not form a definite prolonged beak or rostrum; the three basal joints of the tarsus are densely covered with pubescence beneath, the third joint being divided into two lobes so as to allow the fourth joint being inserted near its base.

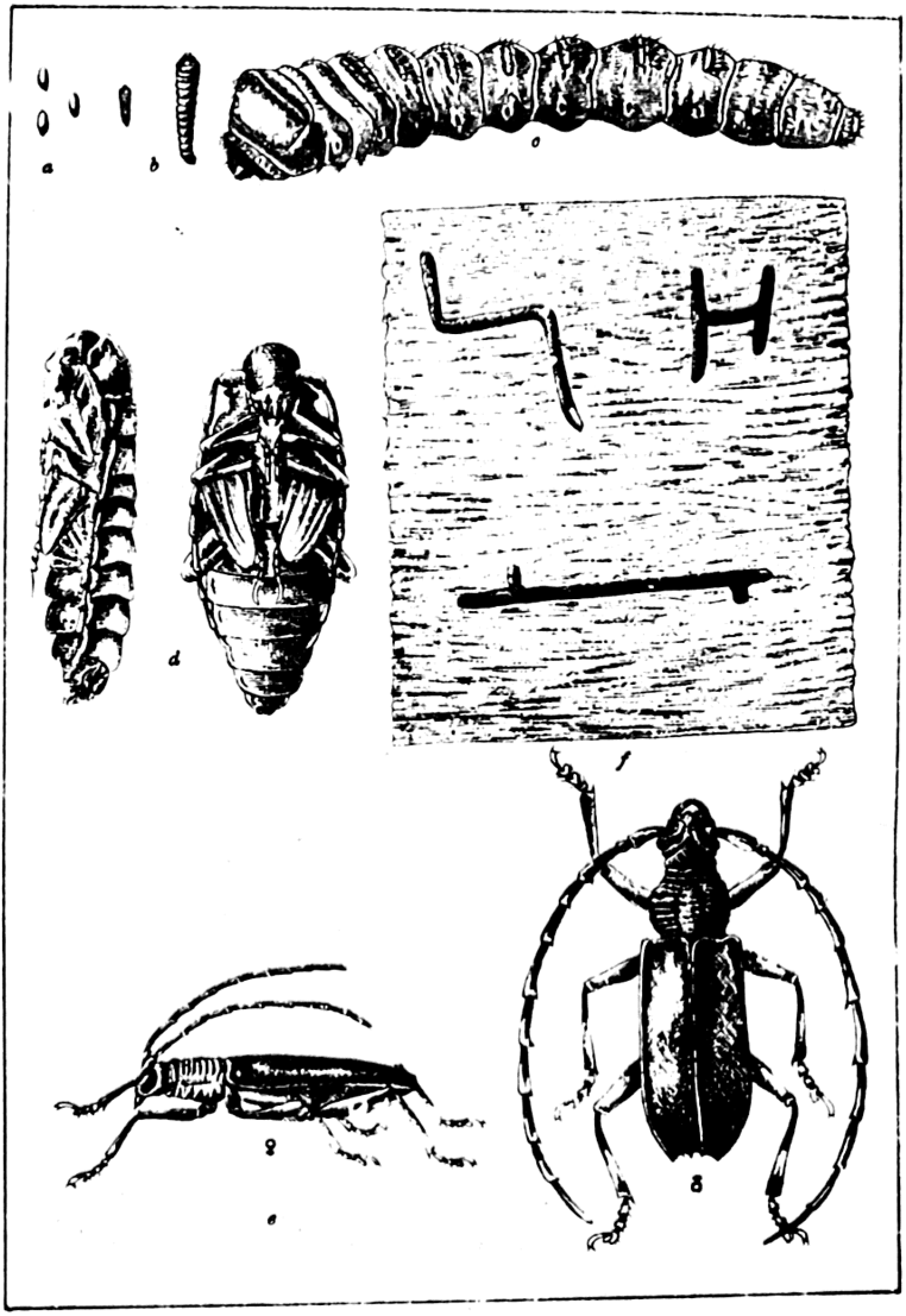
FAMILY XXI.—*Bruchidæ.*

These are small unattractive beetles, having an extremely short prosternum and the hind femora more or less thickened. The front of the head is produced into a short rostrum and the antennæ are bead-like and straight, thus distinguishing them from the *Curculionidæ* where the antennæ are elbowed. The larvæ are little white fat maggots without legs and live in and feed on the seeds of plants, more especially *Leguminosæ*. In India leguminous plants of all kinds are attacked by members of this family, and it is probable that the seed of leguminous forest trees suffers heavily from these pests.

A species of *Caryoborus*, *C. gonagra*, attacks the seeds of *Tamarindus indica* and also of *Bauhinia racemosa* pods in Central Thana, Bombay. The life-history in the case of the Tamarind is as follows:—

Life-history of the Tamarind Bruchid, *Caryoborus gonagra*.

The eggs are probably laid on the pods before they reach maturity between March and May. The larva hatching out makes its way through the pod and tunnels directly into the seed. It has been found that none of the seeds contain more than one grub. When full fed the grub either leaves the seed and spins a close-matted cocoon inside the pod and passes the pupal stage within this or pupates within the empty seed skin itself. The beetle, which is brown in colour and about ¼ inch in length, after emerging from the pupal skin, rests for some time before cutting its way out of the cocoon and pod. The exit hole is usually made near the base of the seed skin and near one edge of the pod. Beetles issue from the pods from February to May. Fig. 188 shows this beetle. Since there is only one set of pods per year the life cycle probably takes a year to pass through. In the case of the Bauhinia seed the larva entirely hollows it out and then pupates in the brown seed skins. A closely allied species attacks the pods of *Albizzia Lebbek* in a similar manner. The seeds are large, flat, and squarish, the pods being 9—12 inches in length. The periods of attack in the Bombay Presidency are the same as those of *gonagra*. Fig. 189 shows this insect and an Albizzia seed with a beetle emerging.



192. The Singbhum Sál-wood borer (*Hoplocerambyx spinicornis*); *a*, eggs; *b*, young larvæ; *c*, full-grown larva; *d*, pupæ; *e*, male and female beetles; *f*, tunnels of week old grubs in the outer sap-wood of a sál stem. (All figures nat. size).

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FAMILY XXII.—*Chrysomelidæ* (Leaf-beetles).

Antennæ moderately long, eyes round and do not at all surround the insertion of the antennæ. The insects are small, bright coloured, and thick set. The head is usually partially sunk into the prothorax and the insects differ in appearance from other tetramerous beetles. Both the adults and larvæ feed upon leaves, and several do much damage in India by defoliating plants. The larvæ are small and active and are sometimes covered with spines on which they carry their cast-off skins as a kind of shelter. The pupæ may be found either on the leaves or in the ground, and several generations may be gone through in the year—a fact which intensifies the insect's capabilities of inflicting damage.

A species of *Melasoma* has been reported as defoliating a willow in the North-West Himalayas, whilst *Mimastra cyanura* feeds upon the leaves of *Grewia asiatica* in the Dun. A species of *Halticides* (fig 190) consumes the leaves of Boswellia serrata near Poona. Haltica sp. has been observed defoliating trees in the Chittagong Hill Tracts. It is a brightly coloured pink beetle with an orange thorax and black spots and patches on its wings (see fig. 191).

FAMILY XXIII.—*Cerambycidæ* (Longicorn Beetles).

A large family of beetles containing from 12,000 to 13,000 known species. In form they are usually elongate with well-marked "shoulders" to the elytra and a vertical or flat head. The antennæ are very long, consisting of long cylindrical joints, often tumid at the nodes. They are held over the back in the position of rest. The eyes are hollowed out round the insertion of the antennæ. The latter are longer in the male than in the female. The first three joints of the tarsus are always large, spongy, bi-lobed, and covered with hairs. The beetles are of all sorts of colours, but rarely metallic (as in the case of the Buprestidæ) being often covered with hair or having hair in tufts on them. The thorax is square in outline and cylindrical, and in most cases spined (*cf.* fig. 195). The ♀ has a long, strong non-extruded ovipositor for laying eggs in crevices. The legs are long and strong.

The larvæ are almost entirely wood-feeders and so are white and soft. They have a broad head and powerful jaws and long body, but have not the enormously developed prothorax of the buprestid larva, which they otherwise greatly resemble; in the longicorn larva the abdominal segments are nearly as broad as the prothorax; it is practically legless

and has four-jointed antennæ (*cf.* fig. 192 c). The grubs often spend their lives burrowing up and down in the wood of trees, making galleries which have usually a squarer section than those of buprestids; before they change into the pupal state they enlarge the end of the tunnel and make a pupal chamber. This chamber may be either made in the heart-wood of the tree, in the sap wood, or in the bark. The beetle on maturing either bores its way out of the tree by the shortest route or crawls up the empty tunnel left by the larva to facilitate its escape from the tree. The pupa is white and soft and has the general appearance of the beetle, being unenclosed in any external skin. The legs and wings are held pressed down against the breast and the antennæ against the sides of the body (*cf.* fig. 192 d). Three sub-families of this family are distinguished, as follows :—

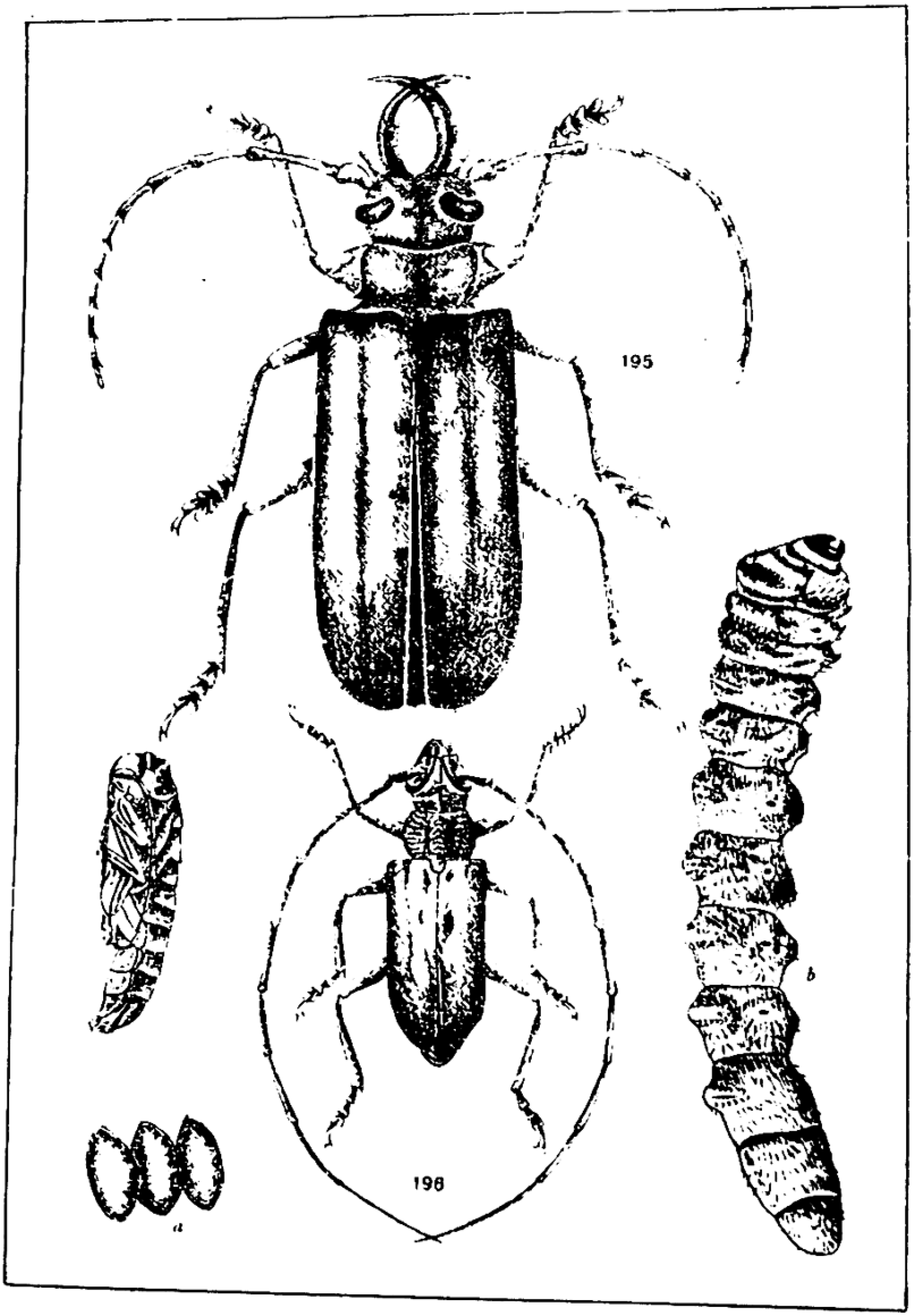
Prionides.—The front coxæ are large and transverse ; the prothorax has distinct side margins.

Ceramb cides.—Front coxæ not greatly extended transversely; thorax not margined. The head is sloped in front obliquely, or at times is almost horizontal. Palpi have the terminal joint truncate and the inner side of the tibia has no groove; small legs are just visible in the larva.

Lamiides.—Front coxæ usually round and deeply embedded; the head is vertical, the terminal joint of palpus is pointed, and the inner side of the tibia has a groove; legs invisible in the larva.

The *Pricnides* are on the average considerably larger in size than the members of the other sub-families, and they include some of the largest of insects. Some have a great develepment of the mandibles in the male sex, analogous to those of the stag-beetle of the *Lucanidæ*. The larvæ in various parts of the world appear to have been a favourite article of food with native tribes. In consequence of the destruction of forests that has taken place so largely in many countries of late years these gigantic cerambycids have become much rarer. *Acantophorus serraticornis* (fig. 195) is a large beetle whose larvæ bore into and riddle sál wood in Chota Nagpur. The beetle is found on the wing in June and on into August. The larvæ probably spend more than one year boring and feeding in the wood.

The modes of life of the larvæ of the Sub-families *Cerambycides* and *Lamiides* are various. Some bore up or down in the hard wood of trees and live for a portion of a year or for several years in this condition before changing to the beetle state. The female beetle in others girdles twigs of trees and then lays her eggs in the branch above the girdle.



195. *Acantophorus serraticornis.*
196. *Æolesthes sartus.* *a*, eggs (*mag.*) ; *b*, larva ; *c*, pupa ; *d*, beetle.

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FIG. 193. Portion of stem of a still green dying Sal tree showing the galleries made by the larvæ of *Hoplocerambyx spinicornis* in the cambium and sap wood *(Original)*.

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FIG. 194. Same stem as shown in *Fig.* 193, split down the centre A full grown larva pupating and several beetles ready to issue, but still *in situ* in the pupating chambers, are shown. The calcareous white covering to the pupal chamber is distinctly visible *(original)*.

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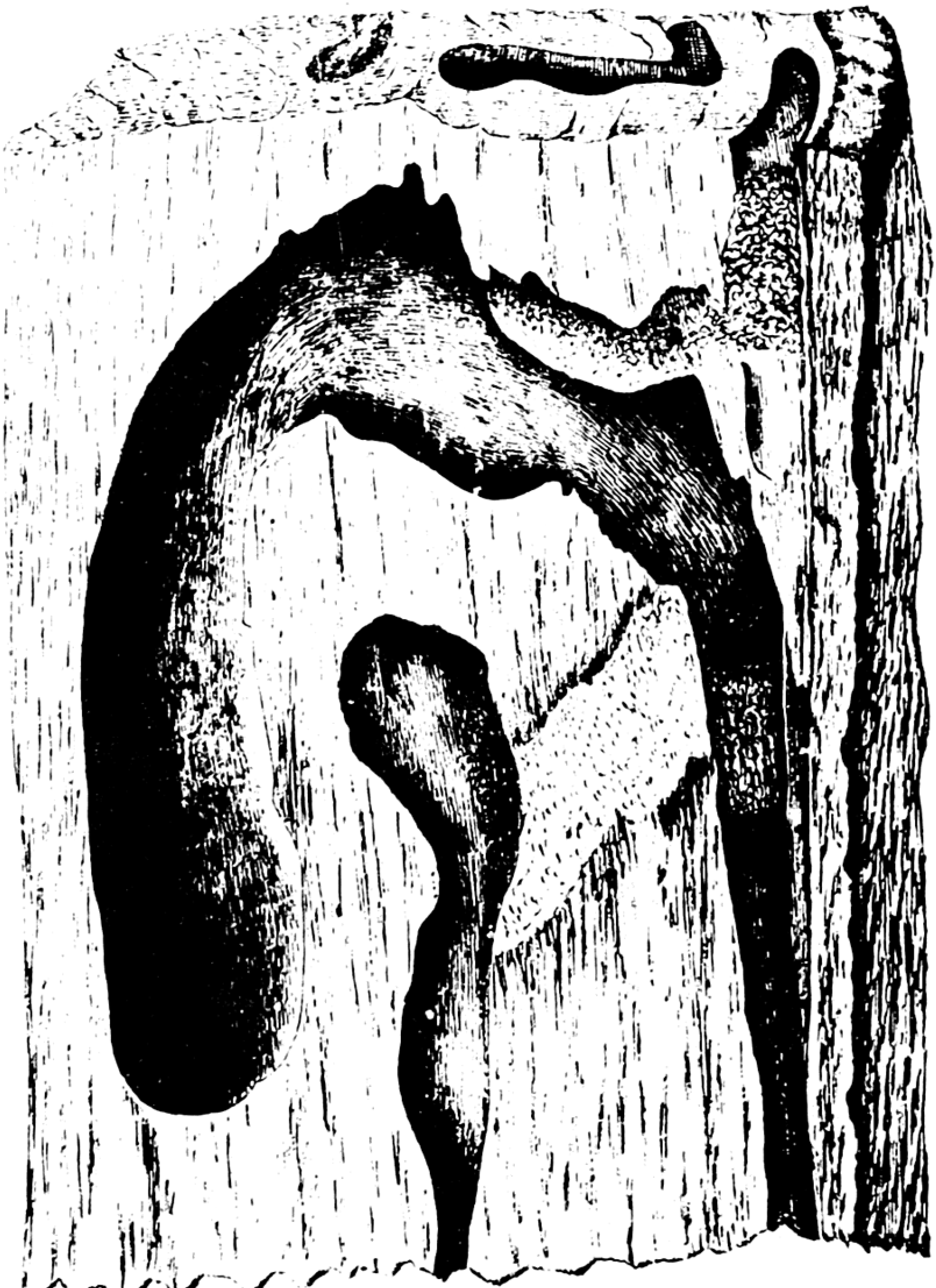

197

197. Portion of a stem of a Poplar tree showing the larval galleries and a pupal chamber of the Quetta-Borer beetle (*Æolesthes* sartus)

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The *Cerambycides* include several serious pests to trees, the following three being typical of the sub-family.

Life-history of *Hoplocerambyx spinicornis*.

Hoplocerambyx spinicornis, or the Singbhum sál-borer, attacks the sál tree in the Central Provinces and Chota Nagpur and in Assam and the Bengal Duars sál tracts. The life cycle appears to take longer to pass through in the drier climate of Central India than is the case in the hot moist one of Assam. A year or less suffices in Assam, whereas double that period is required in the Central Provinces. The eggs (fig. 192 a) are laid by the beetle on the outside of the bark of green felled or sickly standing trees; they are scattered about singly, March and again in May-June being apparently the period of egg-laying. The grubs (b) are about ⅛ inch in length on hatching out and at once bore down through the bark and groove out small galleries in the sap wood. As they increase in size they go deeper into the sap wood, when plentiful destroying both it and the bast layer as shown in fig. 193. When full fed they bore down into the centre of the heart-wood and eat out a pupal chamber in the long axis of the tree (fig. 194). They close this up with a calcareous covering near the lower end of the chamber (fig. 194) and then pupate. The beetle on maturing breaks the cover, crawls up the larval gallery and escapes from the tree. The grubs probably spend some 9—10 months as such, the pupal stage lasting some 2—2½ months. The life-history shows that this insect is equally dangerous to the living tree which it kills by removing all the cambium layer, and to the timber in which it eats out galleries in the heart-wood to pupate in, thus ruining it. Fig. 192 a to f shows the eggs, young and full grown larvæ, pupa, male and female beetles and tunnels of week-old grubs in sap wood. Fig 193 shows the attacks of the grubs and fig. 194 living beetles ready to emerge *in situ* in the pupal chambers in the interior of the tree.*

A closely related species, *Pachydissus holosericeus*, attacks the sál in the Siwaliks, and its galleries are to be found in considerable numbers in the sál posts (tors). As far as present observations go, the sub-family appears to contain the most aggressive of the sál wood-borers.

Life-history of *Aeolesthes sartus*, the Quetta borer.

This is another longicorn beetle, the Quetta-borer, which is extremely destructive to soft wood trees. Poplars, willows, and elms form its host trees in Baluchistan and in these it lays its eggs in wounds or by piercing through the soft bark in May-June. The grubs feed entirely in the bast and sap wood, completely riddling it, thus causing the death of the tree. When mature they bore down into the wood and pupate in the centre of the tree. Fig. 196 a, b, c, shows the larva pupa and beetle and fig. 197 a piece of a stem of a poplar exhibiting the attacks of the larva. This insect increased in such numbers in Quetta, living in the fine avenues of poplar, willow, etc., in the station, that it became necessary to sacrifice

* For a full description *vide* my Monograph on *Some Assam Sal Insects*. For. Bulletin No. 11, 1907.

a large number of the trees, which were felled, cut up, and burnt in the winter of 1905-06, in order to save the as yet uninfested ones.

Life-history of the longicorn wood-borer, *Plocederus obesus.*

The eggs of another beetle *Plocederus obesus*, are laid in crevices in the bark of *Odina wodia*, sál, and other trees about March or April, and the young larva on emerging first feeds on the bark and cambium layer and outer sap wood. As it becomes stronger it goes right down into the heart-wood of the tree, boring large galleries in it. When pupating the larva forms a peculiar solid calcareous cocoon shown in fig. 198 a, in the outer layers of the wood. The insect pupates in August and September, becoming a perfect beetle (fig. 198 b) in November. The beetle remains in the cocoon until March or April of the succeeding year to enable its outer parts to slowly harden, and then cuts its way out of this and out of the wood. Recent observations tend to show that the larva only lives about six months in this stage of its existence in the Siwalik forests, where it is very common in *Odina wodia* and other trees. It is a very common beetle in many parts of India.

Life history of the *Dialages pauper.*

Dialages pauper of which fig. 200 a, b shows the larva and beetle infest green felled and sickly sál trees in Assam (Goalpára). The eggs are laid in the interstices of the bark; the grubs on hatching out eat shallow irregular shaped galleries in the bast and sap wood about 8-12 inches in length. They bore further into the sap wood to pupate. The top of the pupating chamber is closed with a white calcareous cap. Beetles appear in April.

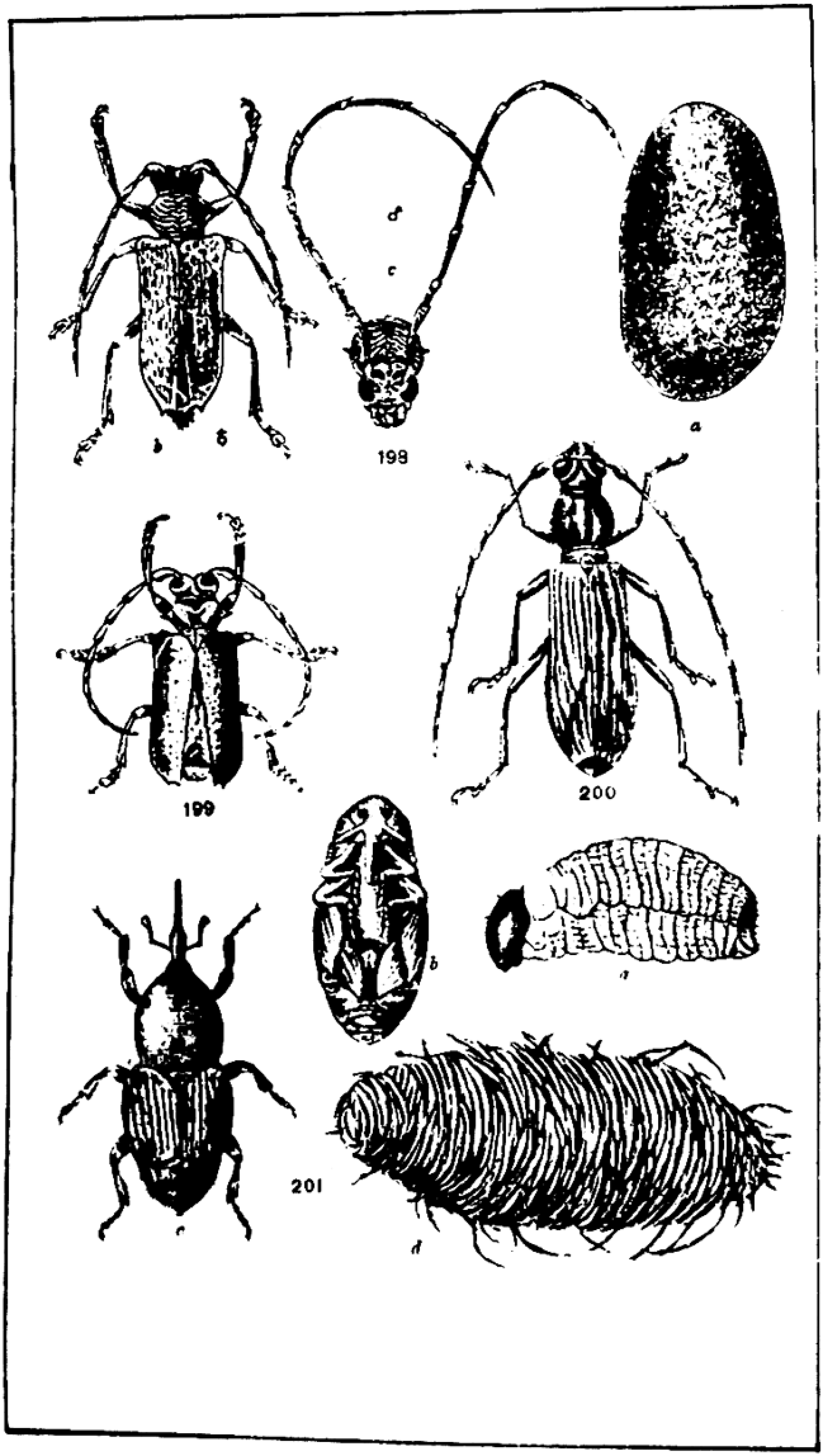
The Lamiides are usually brightly coloured longicorns and would seem to contain species which prefer the softer branches of trees or the tops of young saplings to the hard wood of the stems.

Life-history of the Sál Girdling Longicorn, *Cœlosterna scabrata.*

An example of this sub-family is the beetle known as the sál-girdler, *Cœlosterna scabrata* (fig. 199), whose life-history is as follows:—The female lays her eggs towards the end of the rains in notches in the bark of the shoot somewhere near the upper end, either of a leading shoot or side branch. The beetle then girdles the shoot below the point she has laid her eggs in. The shoot dies above the girdle, and the larvæ on hatching out feed on the dying wood thus provided by the female. They change to the pupa state within this dead portion which will probably by then have been blown or knocked off the tree. The beetle emerges during the rains, laying its eggs towards the end of this season.

Another species, probably a Batocera, has been found peeling off the soft bark of mulberry in the Dun. *Batocera rubus* infests the fig tree in Baluchistan.

The genus *Stromatium* contains several wood-boring members. The eggs appear to be usually laid upon the main stem or branch of young saplings and poles; the grub on emerging bores straight into the heart of the stem or branch and then tunnels downwards. If it is in a branch on reaching the main stem it will tunnel down the centre of that. In this way saplings are killed and the wood of poles ruined, although the tree may not be killed. A species of the genus tunnels in sandal in this way, reducing or ruining the value of the wood. Another, *S. barbatum*, is known as the Kulsi (Assam) teak-borer owing to its killing off young teak



198. *Plocaederus obesus.* *a*, calcareous cocoon containing pupa; *b*, female beetle; *c*, head of male beetle.

199. The Sâl-Girdler (*Coelosterna scabrata*).

200. *Dialeges pauper.*

201. *Rhynchophorus signaticollis.* *a*, larva; *b*, pupa; *c*, beetle; *d*, cocoon made of palm fibres.

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saplings in that plantation. This insect also tunnels into *Dendrocalamus strictus* in the Central Provinces and dry khair wood in the Dehra Museum. In the latter case the eggs were probably laid in the green tree, the beetle issuing after the wood was cut.

The grubs of the genus *Xylotrechus* usually feed in the cambium layer of green trees, pupating in the sap wood. Species are known to attack pyinkadu, sál, Anogeissus (?), *Quercus dilatata,* and other trees. *Xylotrechus quadripes* is the well-known 'coffee-borer' of Southern India.

Rhynchophora.

The head forms a more or less elongated beak or snout. The third tarsal joint at least is usually broad and densely pubescent beneath.

FAMILY XXIV.—*Curculionidæ* (Weevils).

The head is prolonged into a well-marked beak, called the 'rostrum which bears a pair of elbowed clavate antennæ on it and carries the mouth parts at its tip; the antennæ often fold back into a groove placed at the side of the rostrum. The palpi are small and the labium absent. The elytra bend over the side of the abdomen.

The Curculionidæ are an enormous family of beetles, containing about 25,000 known species. They do damage to the wood, leaves, shoots, fruits, and seeds of trees and crops. They have been reported in this connection from many parts of India. The larvæ are white, legless grubs which tunnel into vegetable matter of all kinds.

Life-history of the Palm weevil, *Rhynchophorus signaticollis.*

The Palm weevil (*Rhynchophorus signaticollis*) is a typical example of this family. The female lays its eggs at the base of the leaf stalks on some spot where the stems have been injured. or in the holes drilled by the rhinoceros beetle (*Oryctes*). The larvæ tunnel their way through the heart of the trunk and often kill the tree outright. The pupa is formed in a cocoon of palm fibre in the burrow. The beetles fly at night, being often found in the day in the holes of the rhinoceros beetle; fig. 201 shows the larva, cocoon, pupa, and beetle. The palms in the Saharanpur Botanical Gardens were badly attacked in this way some years ago, several being entirely killed, whilst others were so riddled that they had to be cut down. This beetle is a common and serious pest in parts of Madras, Bombay, and other places in India.* Its range is probably very similar to that of its companion Oryctes.

* There can be no doubt that in valuable plantations the best treatment is to at once cut out and burn entirely all infected trees. Of course to secure permanent good this must be done throughout the whole of the plantations of a district or series of districts, and not only in one or two, as these latter would soon become re-infected from the neighbouring intended areas.

Mahogany, *Pinus khasya*, and dhak have been reported as being tunnelled into by weevils. In the case of the former two the grubs feed in the bast, gnawing out large winding galleries in it. When full fed they eat out a chamber in the sap wood and pupate in it. Fig. 202 shows *Cryptorhynchus* sp., the Pinus khasya weevil and figure 203 the galleries made by the larvæ in the bast layer of the tree. From December to February this insect is to be found in all the stages of larva, pupa, and beetle in the bast and sap wood of the tree. The insect has become a pest at Maymyo where trees have been killed by it. It is also plentiful at Shillong.*

The shoots of the Hill-bamboo (*Dendrocalamus*) are bored into by the weevil *Cyrtotrachelus dux*, and tops so attacked die off.

Life-history of *Cyrtotrachelus longipes*.

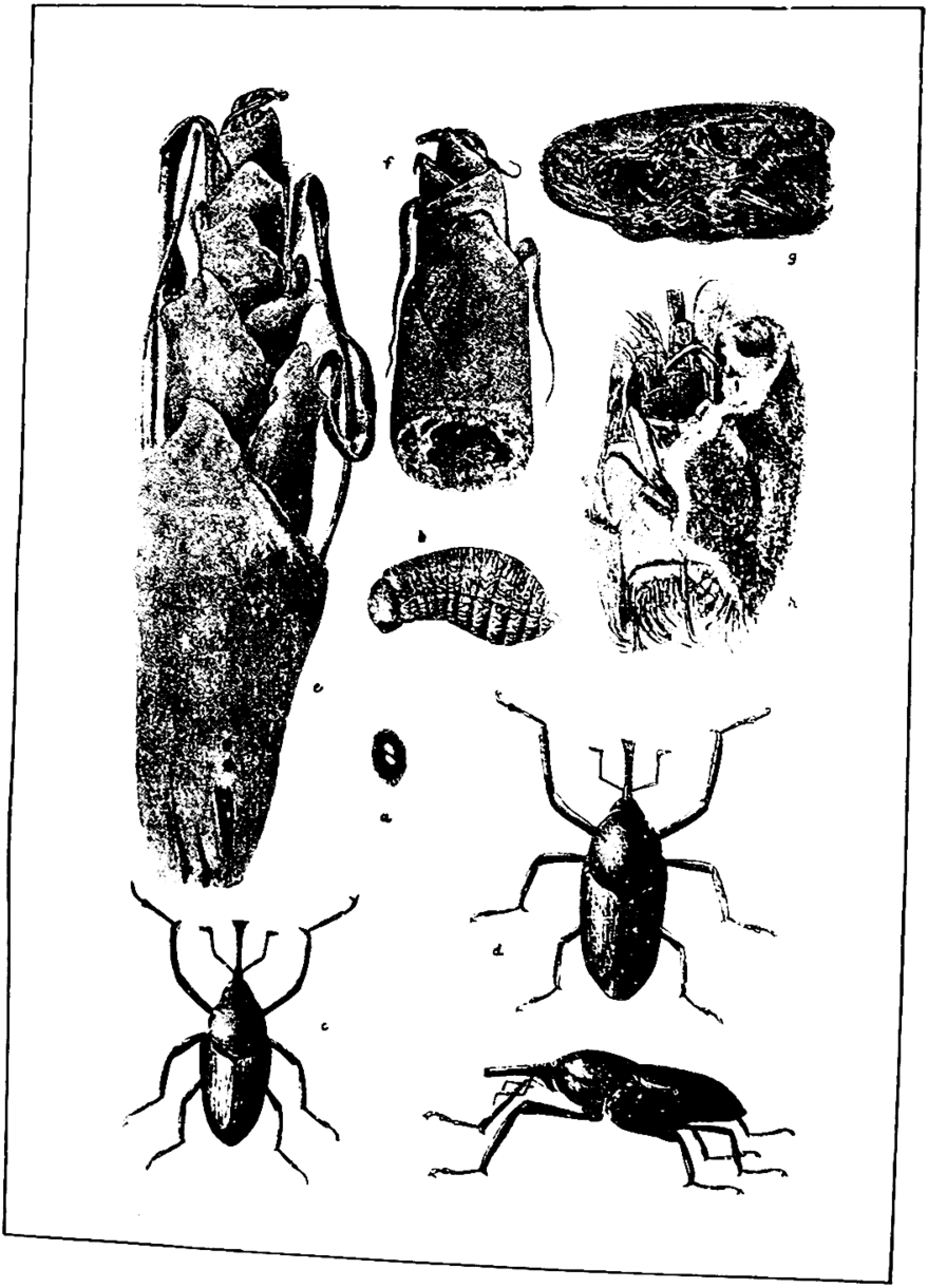
In the Chittagong Hill Tracts a large weevil named *Cyrtotrachelus longipes* attacks young *muli* bamboos (*Melocanna bambusoides*) when they are 1—2 feet above the ground. The female, a large brown beetle with a long rostrum, fairly long elbowed antennæ and enormously developed front legs, lays two eggs on the side of the shoot towards the end of June. Only one of these eggs appears to develop, as only one larva is subsequently found in the shoot. On hatching out, the young larva tunnels directly into the heart of the shoot and then burrows down the centre of it till it reaches the ground level. It then moves back to near the top and cuts the shoot through all round below it; the top containing the grub thus falls to the ground and gets pressed or dragged into the rain-sodden soil. The larva then pupates within the shoot about the end of July and the insect remains in the pupal state all through the heavy rains and winter months, the mature beetle emerging the following June. This insect is capable of doing a very considerable amount of damage to the bamboo, which grows over large areas in the Chittagong Hill Tracts and country to the east. A severe cyclone swept up into this region in October 1897 and cleared a path for some distance through the forest in the hills. The succeeding year the *muli* bamboo came up in dense masses in this cleared area, and this abundance of their food plant probably caused the severe attack experienced from this insect in 1899 and 1900. In fig. 204 all the stages in the life-history of this weevil are shown and also a tunnelled shoot of the bamboo it infests.†

A large species of this or a closely allied genus attacks in a similar manner the large 4- 5-foot high shoots of the Cephalostachyum bamboo in the Lower Burma forests. The grub is well known to the Burmans who hunt for it in the rainy months and eat it—a habit which is also followed by the Chittagong and Lushai Hill people in the case of the *Muli* bamboo pest.

As examples of pure leaf defoliators, where the leaf is eaten as food by the mature insect, the genera *Myllocerus* and *Cyphicerus* may be quoted. Sissu and Acacia are defoliated by the former, the latter by the beetle *Myllocerus acaciæ* shown in fig. 205, whilst teak is attacked in Berar by a species of the latter. Silver fir is also defoliated by a weevil in the North-West Himalayas.

* *Vide* Departmental Notes, I, p. 42.

† *Ibid*, 193.



204 *Cyrtotrachelus longipes*. *a*, eggs; *b*, larva *c*, male beetle, *d*, female beetles; *e*, young *muli* bamboo shoot in which the eggs are laid by the female; *f*, top of bamboo shoot cut off by full-grown larva; the larva pupates within this; *g*, pupal covering with hole cut from within on one side to permit beetle to emerge. *h*, pupal covering after emergence of beetle

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Another genus of small weevils named *Apoderus* defoliates trees for quite another purpose, *i.e.*, to provide a store of food for the grubs. An egg is laid on the apex of the leaf and the latter is rolled up into a roll or ball. Species of this genus have been observed defoliating the sissu, *Quercus incana*, *Q. dilatata*, *Prunus padus*, hazel, *Anogeissus latifolia*, etc., the insects observed being found in places as far apart and under as varying conditions as obtain in the Jaunsar Hills and the Sutlej Valley in the North-West Himalayas on the one hand and the forests of the Satpura Range in the Central Provinces and the Coimbatore Hills in Madras on the other. In ovipositing the female deposits one egg usually, if not invariably, at the apex of the upper side of the leaf and to the right of the mid rib. It then cuts the leaf across about the middle or near the base, either on both sides of the mid-rib, leaving the latter intact, or else right across from one edge to the other, leaving a small portion at one side uncut. The cutting is done first and the egg laid at the apex afterwards. The cut portion of the leaf is then folded inwards down the mid-rib and the leaf is rolled up from apex downwards into a little roll, the edges being neatly tucked in on either side. The roll hangs to the lower part of the leaf till it dries and then drops to the ground. The larva, on hatching out, feeds upon the store of food thus provided for it and probably pupates in the ground. Fig. 206 shows *Apoderus incana* one of these beetles which defoliates the *Quercus incana* in this manner and a portion of an attacked leaf.

The seed of both oak and sál is attacked by weevils and ruined

A weevil known as *Calandra sculpturata* has been reported attacking the acorns of the oak, *Quercus incana*, about 80 per cent. of the seed crop of the trees round Mussoorie being destroyed in 1902. In this case the eggs are laid near or in the flower, and the grubs riddle the acorns. Immature and mature beetles are to be found in these latter in June. Mr. B. O. Coventry was led to this observation owing to his noticing the general absence of natural regeneration of this oak. He collected a large number of acorns to test how many were sound, with the above mentioned result. The larva, beetle, and attacked acorn are depicted in fig. 207.

The grubs of a species of *Alcides* (fig. 208) live in and destroy walnuts in the North West Himalayas.

The mango weevil, *Cryptorrhynchus frigidus*, lays its eggs in the flowers of the mango, and the young grubs get enclosed in the young fruit, in which they burrow about and feed and finally change to pupæ. The beetle on maturing bores its way out.

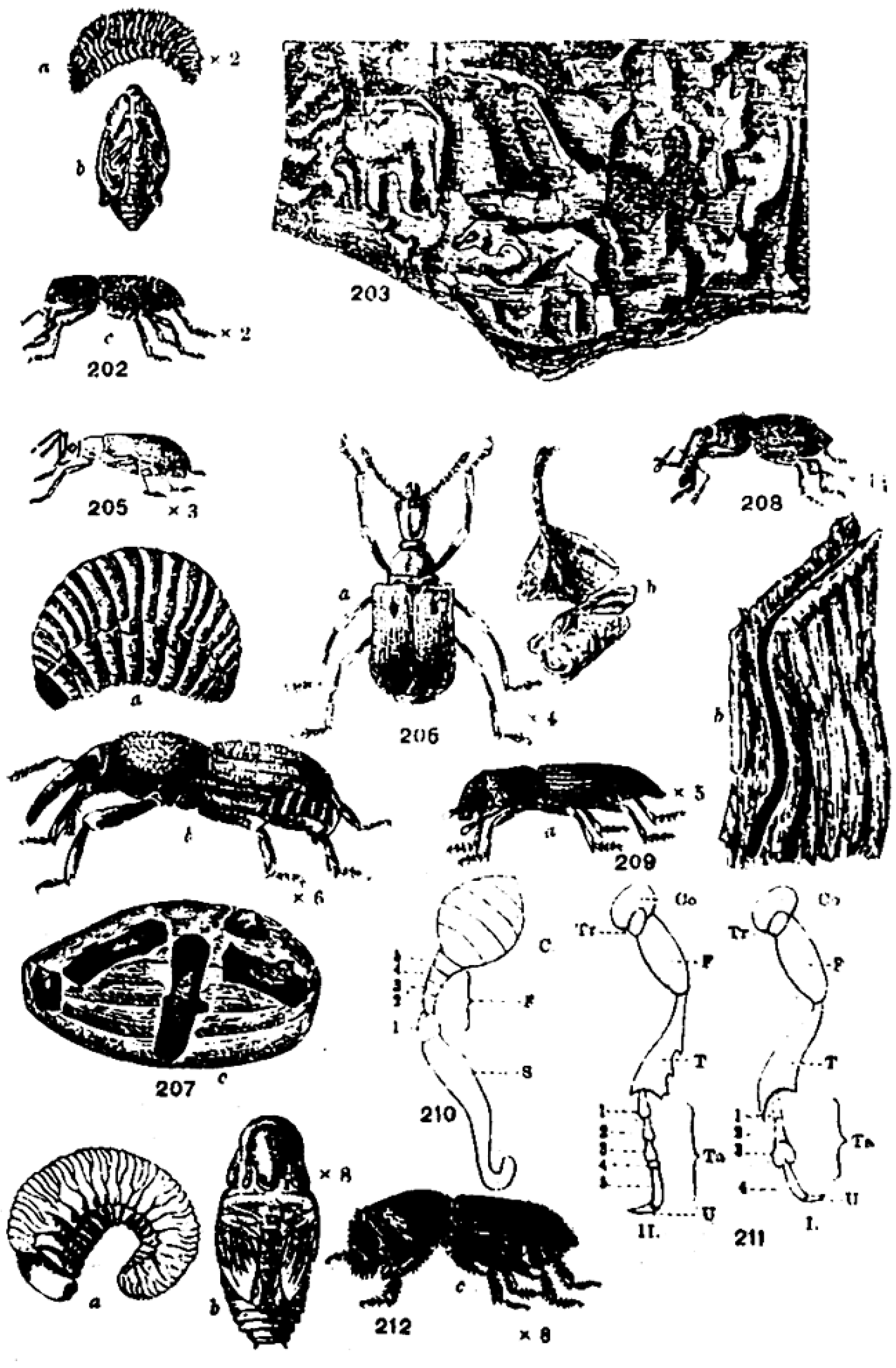
The weevils may be said to merge into the next family, the Scolytidæ, in the curious genus Rhyncholus of which a species (*Rhyncholus* sp.) is depicted in fig. 209 a. The beetle bores into the wood of dead or nearly dead trees, the species attacked being the deodar, blue pine, and spruce. The tunnel is carried down about an inch into the sap wood and the insect then turns and tunnels up the long axis of the tree for about a couple of inches, as shown in

fig. 209 b. The eggs appear to be laid at the end of this long gallery. The larva has not yet been found.

FAMILY XXV.—*Scolytidæ* (Bark-borers).

Small beetles, often very minute. Cylindrical in shape and generally dark brown or black in colour. The head is only prolonged into a very short beak and often not at all; antennæ are short, with a broad club which is elbowed, and inserted close in front of the eye, the latter being often hollowed out to allow of the insertion of the antenna. The antennæ do not fold back into grooves. They may be considered to consist of three main divisions—*1st*, the portion joining on to the head, which is the lower part of the elbow, and consists of only one long joint called the "scape;" *2nd*, the "*funiculus*," consisting of as many as seven joints or fewer; *3rd*, the *club*, which may be solid, or divided by transverse divisions, and varies greatly in shape—*vide* fig. 210. The antennæ are of importance since they are used in the classification of the family. These elbowed antennæ and four-jointed tarsi distinguish these beetles from Bostrichidæ, which they otherwise greatly resemble. The prothorax is generally very long, often forming half the total length of the insect, and the elytra cover the whole abdomen. The tibiæ are flattened laterally, and in the majority the front tibiæ are set with spines on their outer edges (see fig. 211b); the third tarsal joint may or may not be bi-lobed. The larvæ are small white curved grubs resembling bostrichid grubs, but differ in being legless. The pupa is white and has the shape of the future beetle, the legs, antennæ, etc., being free. Fig. 212 shows larva, pupa, and imago of a species of Scolytus, *Scolytus minor*.

These insects feed, as a rule, in woody plants, either in the best layer and sap wood or tunnel right into the heart of the tree. The female burrows through the bark to lay her eggs, and does not usually lay them in crevices outside, as is the case with buprestids and longicorns. The beetles only appear for a short time for egg-laying, but during this period they are often present in large numbers. The majority of the individuals of a generation usually issue from the trees which have reared them about the same time and fly off in swarms to attack suitable ones in the vicinity.



202. *Crypterrhynchus sp.* *a*, larva; *b*, pupa; *c*, beetle.
203. Attacks of grubs in bark of *Pinus Khasya*.
205. *Myllocerus acaciæ*.
206. *Apoderus incana*. *a*, beetle; *b*, rolled-up leaf.
207. *Calandra sculpturata*. *a*, grub; *b*, beetle; *c*, attacks of grubs in acorn.
208. *Alcides sp.*
209. *Rhyncholus sp.* *a*, beetle; *b*, tunnel in wood.
210 Antenna of a Scolytid beetle: S, scape; F, funiculus of five joints; C, club.
211. Front leg of I., Scolytus; II., Polygraphus beetle; Co, coxa; F, femur; T, tibia, Ta, tarsus; U, claw.
212. *Scolytus minor*. *a*, larva; *b*, pupa; *c*, beetle.

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The bark forms, *i.e.*, those members of the family which lay eggs in the bast layer of the tree, as distinguished from the tree wood borers, may be either monogamous or polygamous.

In the monogamous forms the female pairs either outside or inside the tree and then bores through the bark and proceeds to make a gallery in the bast and sap wood, this gallery having a certain definite direction which is always constant for the same species. The beetle may take some days to prepare this. As she bores she makes a series of small depressions on either side in each of which as soon as completed, she lays an egg in a little mass of fresh soft wood dust. The grubs on hatching out eat out galleries which run at an angle from the mother-boring. When full fed the larvæ enlarge the end of their galleries into pupal chambers, which may be either in the bast or may be bored into the sap wood (*cf.* fig. 213). The larval galleries may differ in length and also in direction but the general 'plan' of the egg and larval galleries is always constant for a particu'ar species and different to those made by other and even nearly allied species. This is one of the most economically important characteristics of the *Scolytidæ* to the forester since it enables him to satisfy himself as to the presence or absence of a particular pest in his forest by an inspection of the bark and wood, without it being actually necessary to see the insect himself.

The entrance gallery through the bark may be commenced by the female who then attracts the male near the entrance hole and pairs with him there, or the male may bore a short way into the bark and eat out a small pairing chamber to one side of the short entrance tunnel. The female joins him there either by entering down his tunnel or by boring a separate entrance tunnel of her own which exactly hits off the pairing chamber. In each case, after pairing, the female carries or continues her gallery straight down to the bast layer, and then eats out the egg gallery at a right angle to the entrance one. The female usually remains alive for some time after egg-laying, crawling up and down the egg galleries, which she keeps quite free of wood dust.

In the polygamous forms the male beetle tunnels through the bark till it reaches the sap wood in which it bores a small depression which is the pairing chamber, and there remains. The females either

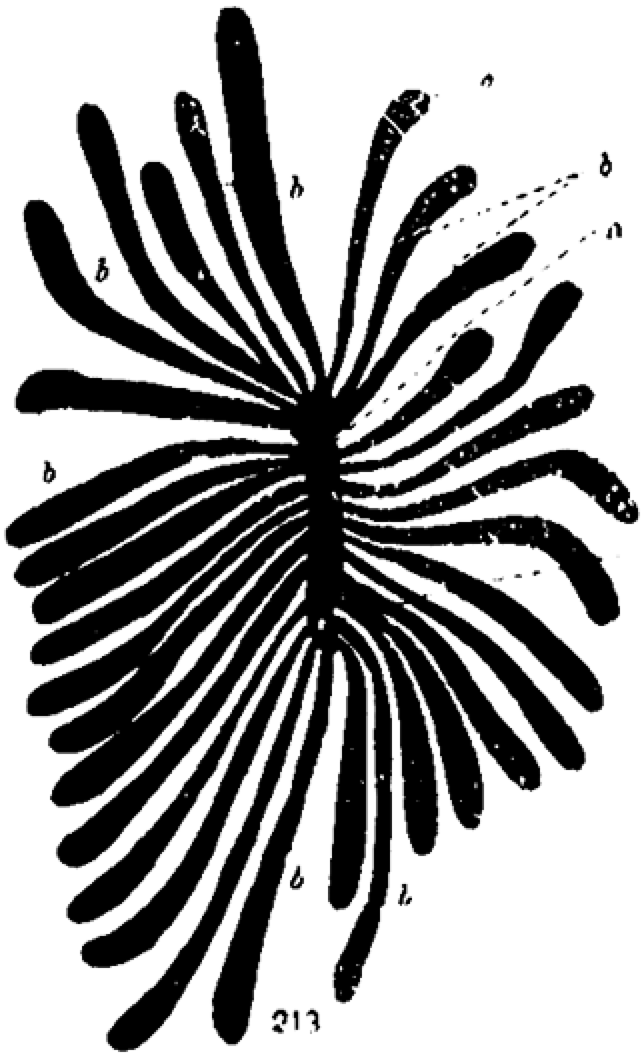
come to him, entering by the hole he has made, or bore their own entrance holes through the bark until they reach the pairing chamber; they are then fertilised and tunnel out galleries leading off from the pairing chamber. On either side of these galleries they bite out small depressions, laying an egg in each. These depressions are not cut at such regular intervals as in the case of the monogamous forms, and when the male pairs with four or five females, four or five egg galleries thus radiating from the pairing chamber, it is observable that the eggs are often laid only on one side of the egg gallery (*cf.* fig. 214) If the egg gallery made by the female is a long one, she bores ventilation holes horizontally through the bark here and there to the outside. These holes are so eaten out that a very thin layer of outer bark is left over them. This suffices to prevent predaceous animals, chiefly insects, from entering the egg chamber to devour the grubs. The 'plan' of the egg and larval galleries is, in the case of the Indian forms at present studied * by the writer, always the same for the same species of beetle. The dead body of the female is often to be found at the end of the egg gallery as she dies as soon as she has finished this work. The egg gallery may or may not be blocked up with wood-dust by the beetle.

Other members of this family feed upon the wood only or their larvæ require wood as food. The beetles bore through the bark down into the wood, the tunnel going straight in or at an angle. At the lower end they eat out several small offset tunnels in which they lay the eggs (*cf.* fig. 215); the grubs on hatching out either enlarge the egg tunnels or they are 'ambrosia' feeders and feed upon certain fungi which line or live on the walls of the tunnels bored by the parents, which latter may have no off-sets (*cf.* fig. 216).

The wood boring Scolytidæ may be either monogamous or polygamous in their habits.

The *Scolytidæ* contain numerous species which are destructive to trees, and research is showing that they probably play a very important part in the Indian forest, attacking both broad-leaved and coniferous trees. In the case of the bark-borers the damage is done by the beetles and the larvæ resulting from the eggs laid by them, both

* *Vide* Departmental Notes on Forests which affect Forestry, Vol. I pp. 203 to 286, 389 to 405, in which a number of new forms are described.



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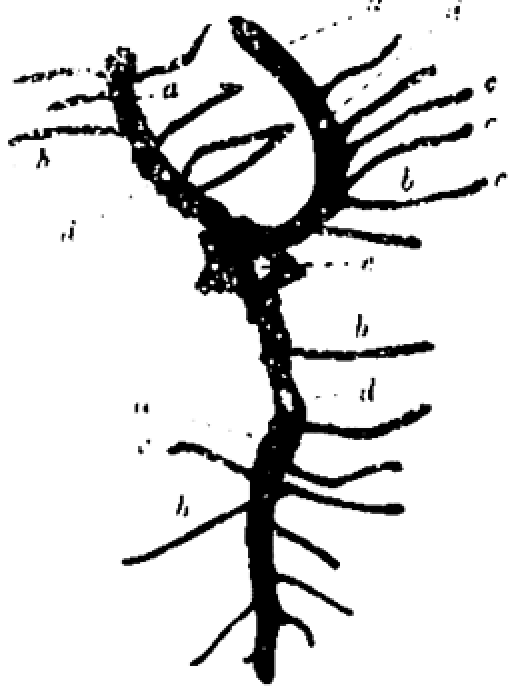

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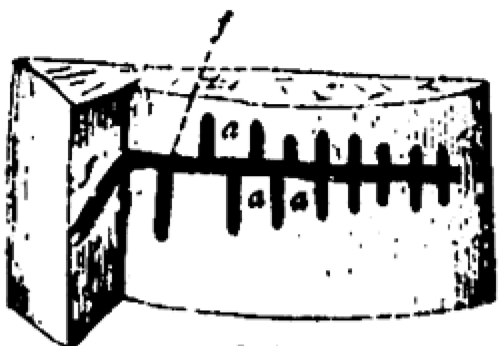

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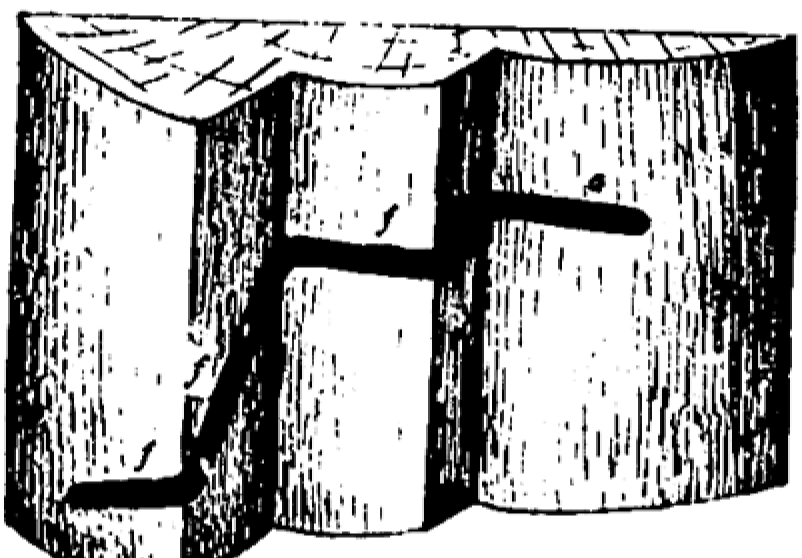

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213. Typical plan of a Monogamous Scolytid Bark-boring beetle.
214. Typical plan of a Polygamous Scolytid Bark-boring beetle.
215. Typical plan of a Scolytid Wood-boring beetle.
216. Typical plan of an 'Ambrosia' feeding Platypid. *a*, egg-gallery; *b*, larval gallery; *c*, pupal chamber; *d*, aeration holes; *e*, pairing chamber; *f*, entrance tunnel of ♂ and ♀ beetles.

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217. Portion of the trunk of a *Pinus Gerardiana* badly infested by *Polygraphus Trenchi*; the bark shows the curious "weeping" effect caused by the exudation of the resin from the entrance holes of the beetles.

218. Branch of Pinus *excelsa* infested with *Polygraphus major*: the circular rims of white resin surrounding the entrance holes are visible.

219. Examples of the 3 sub-families of the *Scolytidæ*. *a*, *Solcytus* and leg; *b*, *Polygraphus* and leg; *c*, *Tomicus* and leg.

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of whom bore under the bark in the bast layer, their excavations destroying this latter and leaving an indelible impression of their former presence either in the bark or in the sap wood, or both, of the tree. When severe attacks have been experienced, if the bark be removed, both it and the sap wood will be seen to be completely covered, sometimes from the top to the base of the tree, with the galleries of the beetles and their grubs. Now, as in making each of these galleries a certain amount of cambium has been destroyed, it therefore follows that the strength of the tree has been lessened thereby, and when the attacks are on a large scale the tree will die. The insects do not usually attack healthy trees, but choose either newly felled or sickly ones in which the flow of sap is less strong. When the beetles are very numerous, however, and no sickly trees or newly felled ones are available, they will attack healthy ones. In the first attacks numbers are drowned in their partially-constructed burrows by the flow of sap put out by the tree in response to the attack, but this flow becomes gradually weaker and weaker, and the beetles finally gain the upper hand and kill the tree.

Coinferous trees infested by bark-boring Scolytidæ can easily be distinguished by the following :—

(*a*) The foliage turns yellow and commences to drop.

(*b*) The trunk shows on the outside beneath the entrance hole an elongate pear-shaped drop or tear of resin. Trees so affected are said to be 'weeping,' and when badly attacked these 'tears' are very numerous and easily visible (*vide* fig. 217). In the case of a branch the entrance hole is usually marked by an elevate circular rim of white resin as depicted in fig. 218.

Little is at present known about the wood-boring forms. They are very numerous and attack the wood in various degree of dryness, some boring into the newly felled tree or the sickly green tree standing in the forest, whilst others only tunnel into timber which has reached a more or less advanced stage of seasoning.

The family may be divided into three main sub-families: the *SCOLYTINI*, *HYLESINI*, and *TOMICINI*. These sub-families are easily distinguished by the different conformation of the end of the abdomen in each; the entire front tibia in the Scolytini also separates

it from the toothed ones in the other two groups (*vide* fig. 219 *a.b.c.*).

The *SCOLYTINI* can be distinguished by having the end of the abdomen flexed upwards and the tibiæ are entire on their outer edges and end in a hook.

Life-history of *Scolytus major*.

The genus *Scolytus*, which confines its attacks to broad-leaved trees in Europe, has been found to attack the deodar in India. It also attacks coniferous trees in America.

The following is the life-history of one of the Indian species, *Scolytus major*, Steb.* The beetle is a monogamous one, the female pairing with the male outside the trees. The eggs are laid in the bast and sap wood, and to do this the beetle bores horizontally through the bark until she reaches the cambium layer, the entrance hole being generally beneath a branch or flake of bark. The female then turns and bores her egg gallery (220 a) in an upward direction, grooving both bark and sap wood. This egg gallery consists of a number of small continuous zig-zag curves taken vertically up the tree. On either side of the groove indentations are cut and an egg is laid in each, from 60—70 being deposited. The larvæ, on hatching out, eat out galleries (b, b) in a direction away from the mother one at various angles, so that the figures impressed on the wood and bark consist of a number of radiating larval galleries, longer than the female gallery, which give off from the central mother tunnel. This plan of gallery, forming an elongate ellipse (*vide* fig. 220), is very characteristic of the genus *Scolytus*. The beetles oviposit towards the end of May, the larvæ are full grown in a month, pupate at the end of the galleries (c, c), and the mature insects issue during June and July and at once pair and lay eggs, the latter producing a second generation of the pest the same year, *i.e.*, fresh beetles mature about October. A closely related species, *Scolytus minor* Steb., (fig. 212) smaller than the last, is usually found in company with it and lives in exactly the same manner. Its galleries are smaller and fewer eggs are laid. Fellings in the deodar forests usually commence in April and continue on into the summer. This practice, in the cases where the trees are not barked, assists the rapid increase of these beetles since numbers of newly felled trees are present in the forest at the periods at which the beetles flight and oviposit.

Another species of *Scolytus*, *S. deodara* (fig. 221 *a*), occurs in the N.-W. Himalayas. This beetle girdles green deodar branches in June and lays its eggs in the part of the branch above the girdle. The young larvæ on hatching out eat out tunnels in the bark and sap wood of the drying branch (fig. 221*b*); before pupating they enlarge the end of their tunnel in the sap wood. The reason for girdling the branch is to ensure the provision of dying wood for the larvæ. The length of the larval gallery is never more than 2—3 inches whilst the branches ringed are often several feet in length, the insect thus girdling

Life-history of *Scolytus deodare*.

* This beetle is allied to *Scolytus destructor* of Europe. For further information on its life-history, *vide* Departmental Notes on Insects that affect Forestry, Vol. I, pp. 45 and 203.

220. Egg and larval galleries of *Scolytus major*, and *Scolytus minor*, in Deodar wood. *a*, egg gallery; *b*, larval galleries; *c*, pupal chamber at end of larval gallery.

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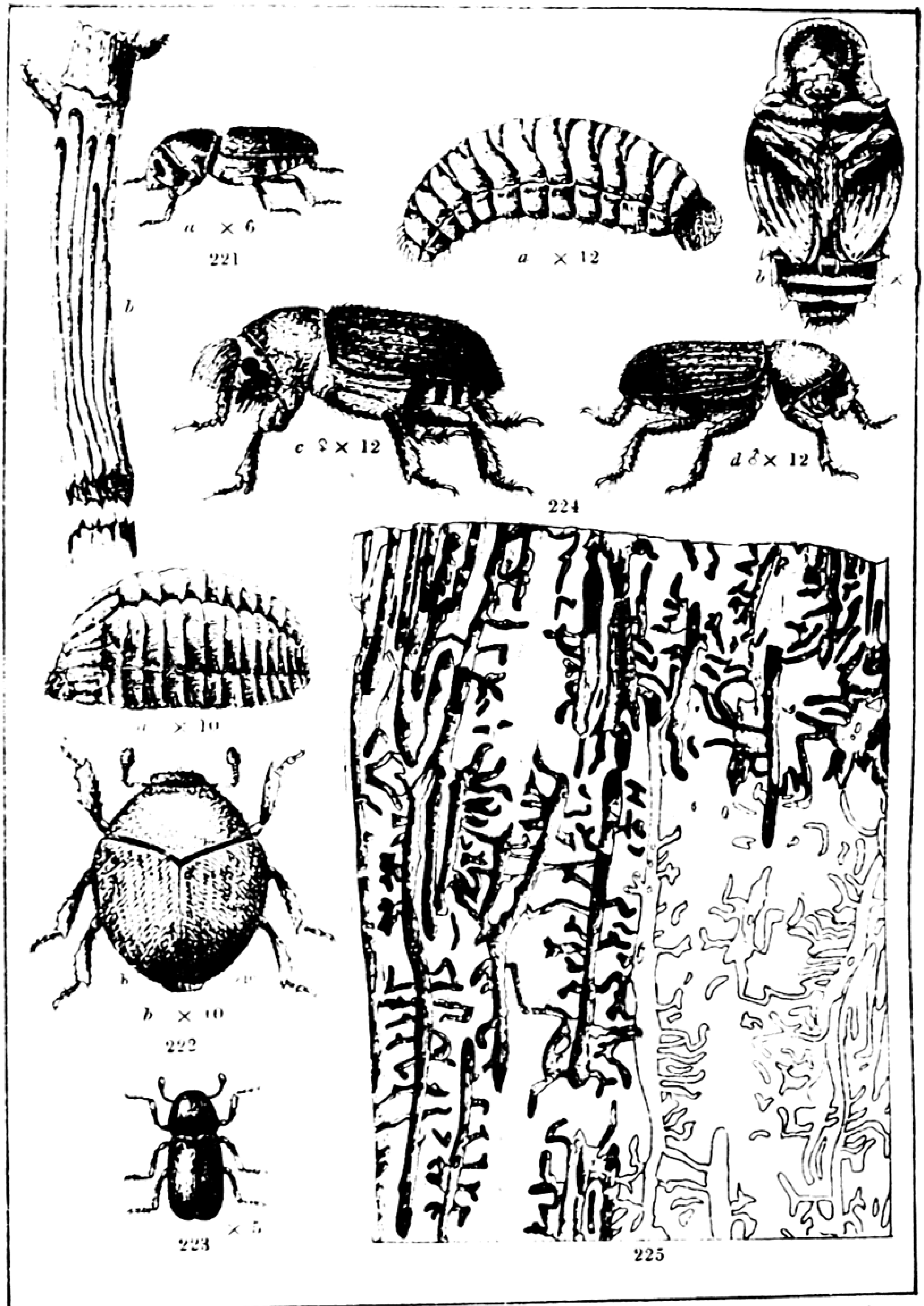

221. *Scolytus deodara.* *a*, beetle ; *b*, girdled branch with bark removed, showing the girdle and galleries made by larvæ in wood above it.

222. *Sphærotrypes siwalikensis.* *a*, larva ; *b*, beetle.

223. *Polygraphus major.*

224. *Polygraphus Trenchi.* *a*, larva , *b*, pupa ; *c*, female , *d*, male beetles.

225. Inner side of a piece of bark of *Pinus Gerardiana* showing egg and larval galleries made by this insect.

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far below a point which would suffice for what its larvæ require. The beetles mature and issue in July. There may be a second generation of the pest in the year. Both old and young trees are treated in this way by the beetle, the leaders of saplings being often girdled and killed.

The *HYLESINI* may be distinguished from the *Scolytini* owing to the abdomen being flat beneath instead of flexed upwards, whilst the tibiæ are toothed on their outer edges. This division contains both monogamous and polygamous forms. Species of the former, *e.g.*, *Sphaerotrypes* have been found by the writer,—to give but three instances,—attacking sál trees in the Siwaliks and Assam, and *Anogeissus latifolia* in the Coimbatore forests (in Madras) in a very similar manner.

Life-history of *Sphaerotrypes Siwalikensis*.

The male beetle tunnels a little way into the bark and then eats out in it a pairing chamber as described above. The female bores a separate tunnel to meet the pairing chamber, and on reaching it pairs with the male. She then continues her tunnel down to the cambium layer and mines out in this and the sap wood a short straight egg gallery parallel to the long axis of the tree. Eggs are laid in notches on either side of this gallery. The larvæ on hatching out bore away at an angle to the egg gallery, and the pattern produced is not unlike that made by a *Scolytus*, but the ellipse is rounder and blunter, the egg gallery being straight. Fig. 222 *a. b. c.* shows the larva, pupa and beetle and fig. 213 the galleries in the bark. The sál beetle here described has three, if not four generations in the year. The species of this genus attacking the sál in Assam and Anogeissus in Coimbatore act in the same manner.

Amongst the Indian polygamous forest *Hylesini* as yet known there are species of *Polygraphus* and *Pityogenes*, etc. Two species of *Polygraphus* are to be found attacking the blue pine in the N.-W. Himalayas, and they also infest the deodar and spruce. The largest one, *Polygraphus major*, Steb., confines itself to the tops and branches. There is a central pairing chamber made by the male from which usually three egg galleries are bored by the females. The larvæ feed wholly in the bast layer, but pupate in the sap wood, boring a depression or hole in it. There are at least three generations of the insect in the year. Fig. 223 shows the larva and beetle.

Life-history of *Polygraphus major*.

The life-history of *Polygraphus minor*, Steb., is very similar save that it practically confines itself to the main stem of the tree, where it is almost invariably the companion of the blue pine *Tomicus* (see below).

Life-history of *Polygraphus Trenchi*.

Another species of Polygraphus, *P. Trenchi*, Steb., is a serious pest of the Chilgoza pine (*P. Gerardiana*) in the North Zhob pine forests of Baluchistan. The insect infests the trunk and all the large branches of the tree. The male bores down and eats out a pairing chamber in the sap wood. Three or four females enter and pair with him, the first and third carrying their egg galleries vertically upwards, the second and fourth downwards. The egg galleries are long

and have two or three æration holes bored at right angles through the bark, a thin covering being left on the outside. This insect runs through three or four generations in the year. The beetle attacks living standing trees: attacked trees can be detected by the foliage turning yellow and by the numerous pear-shaped drops of resin on the bark (fig. 217).* Fig. 224 shows this beetle and fig. 225 the egg and larval galleries in the bast layer of the tree.

The *TOMICINI* are distinguished by having the ends of their elytra truncate, the head is spherical and hidden beneath the prothorax, which is often covered with projections and asperities; the third tarsal joint is simple. Several species of this division of the *Scolytidæ*, both monogamous and polygamous forms, are already known in India †

Amongst the former may be mentioned members of the genus *Cryphalus*. These beetles are very minute, usually light brown or yellowish in colour and often covered with a whitish pubescence. They are generally to be found in the smaller branches of trees or in the tops of saplings. The male and female beetles bore through the bark, often entering by different holes. In the bark they excavate an irregular chamber after which they pair and the male leaves the tree The female then enlarges the pairing chamber and lays her eggs in it, covering them over with fine saw-dust. The larvæ on hatching out simply enlarge their chamber by eating it away on one or more sides. Several generations are passed through in the year. It is not improbable that it will be found that most forest trees in the country have a member of this genus present in the bast layer of their branches. Species have already been found infesting the following trees:— Teak, *Boswellia serrata*, spruce, *Pinus longifolia*, and deodar. Fig. 226 shows the beetle *Cryphalus Boswelliae*.

Another monogamous beetle of this group is a species of *Hylastes* (fig. 227) which has been discovered in the North-West Himalayan forests. *Hylastes* sp. bores into the decaying and dead wood of blue pine and spruce trees. The beetles pair inside the wood and the female then continues the tunnel and lays eggs in small offsets eaten out at right angles from it.

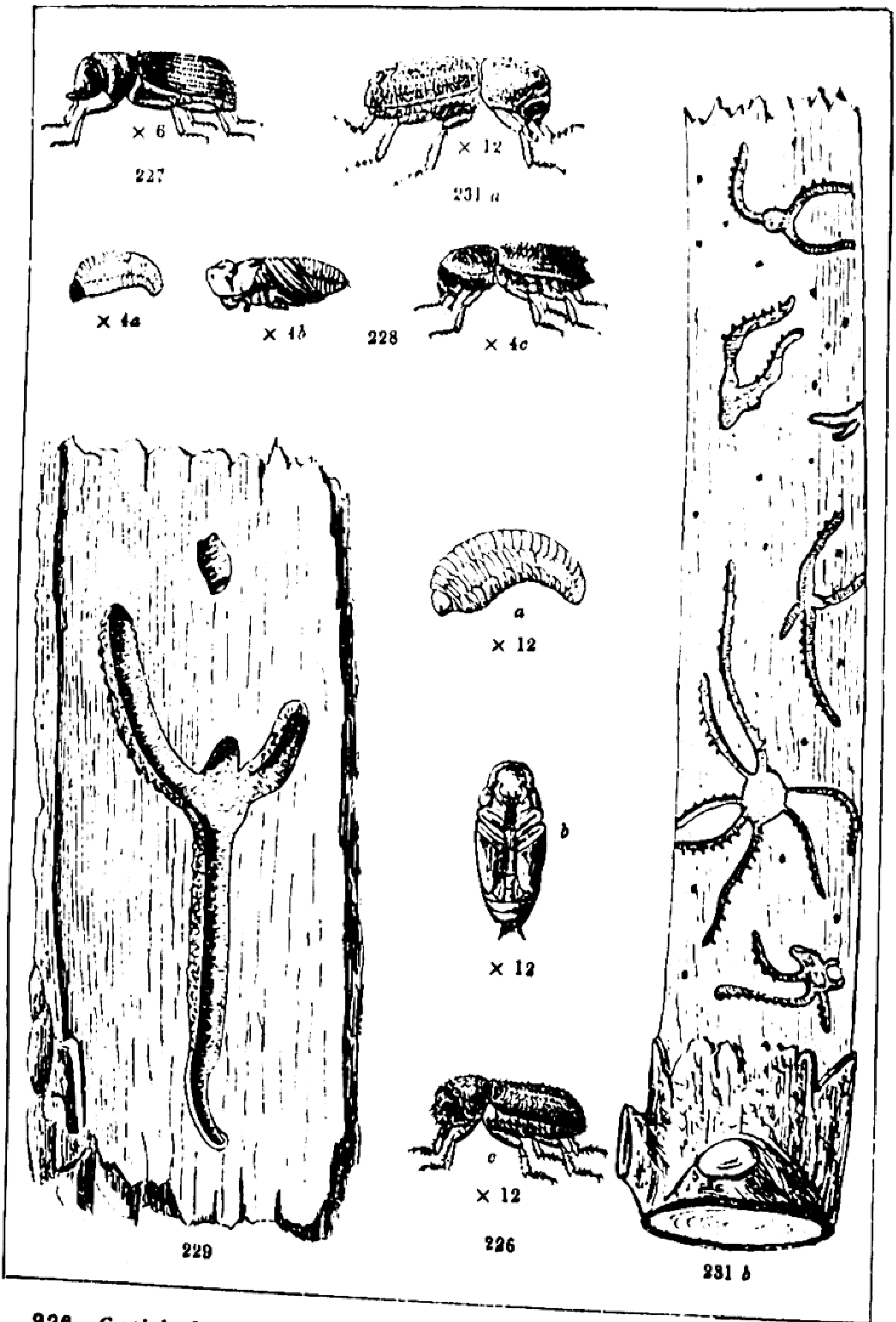
Life-history of *Hylastes* p.

An example of a polygamous beetle of this division is the Blue Pine *Tomicus*, *Tomicus* sp., (larva, pupa and beetle shown in fig. 288 *a. b.c.*) which is at times very abundant in blue pine and spruce trees in the N.-W. Himalayas and is a source of very considerable injury to them. The beetles commence laying the first batch of eggs of the year at the end of April or in the first week of May. The male bores into the bast layer and makes a pairing chamber (p) in the sap wood; the females enter, and after pairing with the male, mine away from the pairing chamber (fig. 229), their egg galleries (e, e) running more or less in the long axis of the

Life-history of *Tomicus sp.*, *the Blue pine Tomicus.*

* *Vide* the Note on the Chilgoza bark-boring beetles of Zhob by the author (1905).

† *Vide* Departmental Notes on Insects that affect Forestry, Vol. I, pp. 225 and 261.



226. *Cryphalus boswelliæ.* *a*, larva ; *b*, pupa ; *c*, beetle.
227. *Hylastes sp.*
228. *Tomicus sp.* *a*, larva ; *b*, pupa ; *c*, beetle.
229. Partially-formed egg galleries of *Tomicus sp.*
231 *Pityogenes coniferæ.* *a*, male beetle ; *b*, pine branch showing egg galleries of this beetle.

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tree; from three to five such galleries are made, eggs being laid in notches at their sides. The larvæ, on hatching out, feed in the bast layer and sap wood. They pupate in the bast. Fig. 230 shows a piece of blue pine bark covered with the egg (e) and larval (l) galleries of this Tomicus. Three, if not four, generations of these beetles are produced in the year, and at times they swarm so plentifully that the inner surface of the bast and the sap wood appear to be almost black with beetles.

Species of Tomicus, *T. longifolia*, have also been found attacking Pinus longifolia and P. Gerardiana in the same manner.

Pityogenes coniferæ, Steb., is a minute beetle which has usually 5—6 egg galleries radiating in a stellate manner from the central pairing chamber. It often pupates in the sap wood, and is to be found in the blue pine, chilgoza pine, and deodar—at times in enormous numbers. It has at least four, and probably more, generations in the year. It infests all parts of the tree. Fig 231 *a* shows the beetle and, *b*, the egg and larval galleries.

Xyleborus is a wood-boring genus of this sub-family. It is very numerously represented in this country. *Xyleborus perforans* (fig. 232) obtained a wide notoriety some years ago owing to its habit of riddling the staves of beer casks. The same species, or a close ally, has since been found riddling dry sál logs. Other species of this or allied genera have been found tunnelling into both green and dry teak, sál, Terminalia, and other timber trees of the forests.

FAMILY XXVI.—*Platypodæ* (Platypides of some authors).*

These insects are the most aberrant of all *Rhynchophora*, the head being very short, flat in front, with the mouth placed on the under-side of the head, there being no trace of a rostrum; the tarsi are elongate and slender, the third joint not at all lobed, whilst the true fourth joint is visible. The beetles are of a narrow, elongate form, the thorax being very long and the elytra broadly and longitudinally channelled and each curved round at the extremity forming a calliper-like arrangement.

The grub is elongate, straight, and not curved as in the Scolytidæ, almost cylindrical and legless, the head being fairly large and well developed. The body constricts gradually behind, the last segment being oblique and blunt. A flat plate of chitin covers the thoracic segments dorsally. The pupa is elongate and white.

* From a study of numerous Indian species I am unable to look upon these insects in any other light than as a distinct family. Both in the structure and form of the beetle and that of its grub and pupa they differ markedly from the *Scolytidæ*. The difference is equally noticeable in the habits of the two families.

These beetles bore into the wood of trees and stumps, and are proving to be somewhat numerous in the country. The beetles drill cylindrical holes right down into the heart-wood of trees and then lay their eggs at the bottom. The larvæ on hatching out feed upon fungus substances which grow in the walls of the tunnel made by the male and female beetles. It is owing to this curious method of obtaining their nutrition that they have acquired the name of 'ambrosia' beetles.

The beetles tunnel into green standing or felled trees and also into partly dry ones, but observations seem to show that they will not touch very dry wood. The presence of the bark on the wood is immaterial since the beetles bore equally readily into the ends of logs as through the bark on the sides.

Life-history of Crossotarsus coniferae.

During the last few years considerable researches have been made into the life-histories of species of this family. Newly felled deodar trees are at once attacked by a species, *Crossotarsus coniferæ*, Steb., (fig. 233) in the North-West Himalayas. This beetle bores straight down through the bark into the heart-wood of the tree making a cylindrical tunnel in which both male and female beetles are to be found. The eggs are laid at the bottom of this tunnel in June and larvæ are present in the tunnels in July. The beetles sometimes appear very numerously and attack the tree in company with *Scolytus major* and *minor*. Another species infests the spruce in the same manner.

Platypus sp. is a common beetle in the Assam sál forests where it tunnels into the wood of newly felled sál trees, or sickly standing ones, for egg-laying purposes. A generation of the beetle is to be found on the wing at the commencement of May; the insect probably posses through 3 to 4 or more in the year. Fig. 234 shows this beetle.

One, if not two, species of the genus *Diapus* (*D impressus*) bore tunnels in a similar manner into the *ban* oak (*Quercus incana*) in the North-West Himalayas. The egg tunnels are eaten out at the beginning of June, larvæ being present in the tunnels in July. *D. talurae*, of which the fig 235, *a*, *b* shows the larva and beetle, bores into Shorea taluræ in the Coimbatore forests in Madras. The beetle egg-lays in July, young larvæ being found at the end of the month.

Another member of this or a closely allied genus is *D.* (?) *heritieræ* (fig. 236) a platypid which seriously infests sundri (*Heritiera littoralis*) in the Sundarbans in Bengal. At times this insect completely riddles the wood. The beetles appear in April and tunnel into the wood, their galleries going right down into the heart. A few eggs only are laid in the gallery. By June the beetles maturing from these eggs pair, and in their turn tunnel into sundri and lay eggs. There are therefore at least two generations in the year. The beetles will only touch fresh or comparatively fresh wood. They will not touch dry sundri.

ig 230 - Galleries of the blue Pine Tomicus, Tomicus sp in the bark of the Blue Pine, Pinus Excelsa
p. pairing chamber, e, egg galleries, l, larval galleries

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Other species have been found tunnelling into newly felled *Nauclea sessilifolia* trees in January in Tharrawaddy, into newly felled sál trees in May in Assam and into *Pinus longifolia* in the North-West Himalayas. The species boring into this latter tree was supposed to be identical with the 'Ghoon' or 'shot borer' of the bamboo. There is little doubt that these beetles find out newly felled or sickly trees just as readily as the Scolytid bark-borers do.

FAMILY XXVII.—*Brenthidæ*.

Elongate beetles. The rostrum is straight, not bent over at an angle as in weevils, and often very thick. The antennæ are not elbowed. This is a tropical family of beetles about which very little is at present known in India. Some are stated to be wood-feeders, whilst other forms are predaceous, their larvæ entering the burrows of wood-eating beetles to search and feed upon their larvæ. The rostrum is often used for boring holes in wood or bark, an egg being subsequently laid in the hole so made. The males of these insects often differ entirely in appearance from the females.

A member of this family (Brenthus sp.) tunnels into sál wood in Assam; both grubs and immature and mature beetles have been obtained from newly felled and half dry trees in the latter half of May. A pupa and nearly mature beetle have also been cut out of the wood of *Pterospermum acerifolium* in the Darrang evergreen forests in North Assam in April. Fig. 237 shows the beetle, *Brenthus* sp. which bores into dead *Terminalia tomentosa* trees in the sal forests of the Dun, United Provinces.

Trimera.

The tarsi are apparently three-jointed. Other characters are variable.

FAMILY XXVIII.—*Coccinellidæ* (Lady-bird Beetles).

Small, often somewhat brightly coloured beetles with the elytra spotted; first two joints of the tarsi are pubescent beneath. Head is concealed by the thorax. Antennæ are slightly clubbed. The larvæ vary in shape and markings, some being small coloured grubs covered with spines; they are often very conspicuous. When changing to the pupal state they often attach themselves to a leaf of a plant. One small division of the family are plant feeders, but the greater bulk prey upon other insects and are exceedingly carnivorous. They destroy wholesale plant lice, scale insects, etc., which are injurious to cultivated plants. In this way they do immense service

to man. A study of this family in India is likely to prove of the very greatest use since it is probable that it contains many members which are most valuable allies both to the forester and the agriculturist. An instance of this kind will be given here, the life-history being that of a lady-bird beetle, *Vedalia Guérinii*, predaceous upon a *Monophlebus* scale insect, *Monophlebus stebbingi*, which during recent years has appeared in enormous numbers and committed serious injury in the Siwalik and adjacent sál forests in the United Provinces and Punjab.

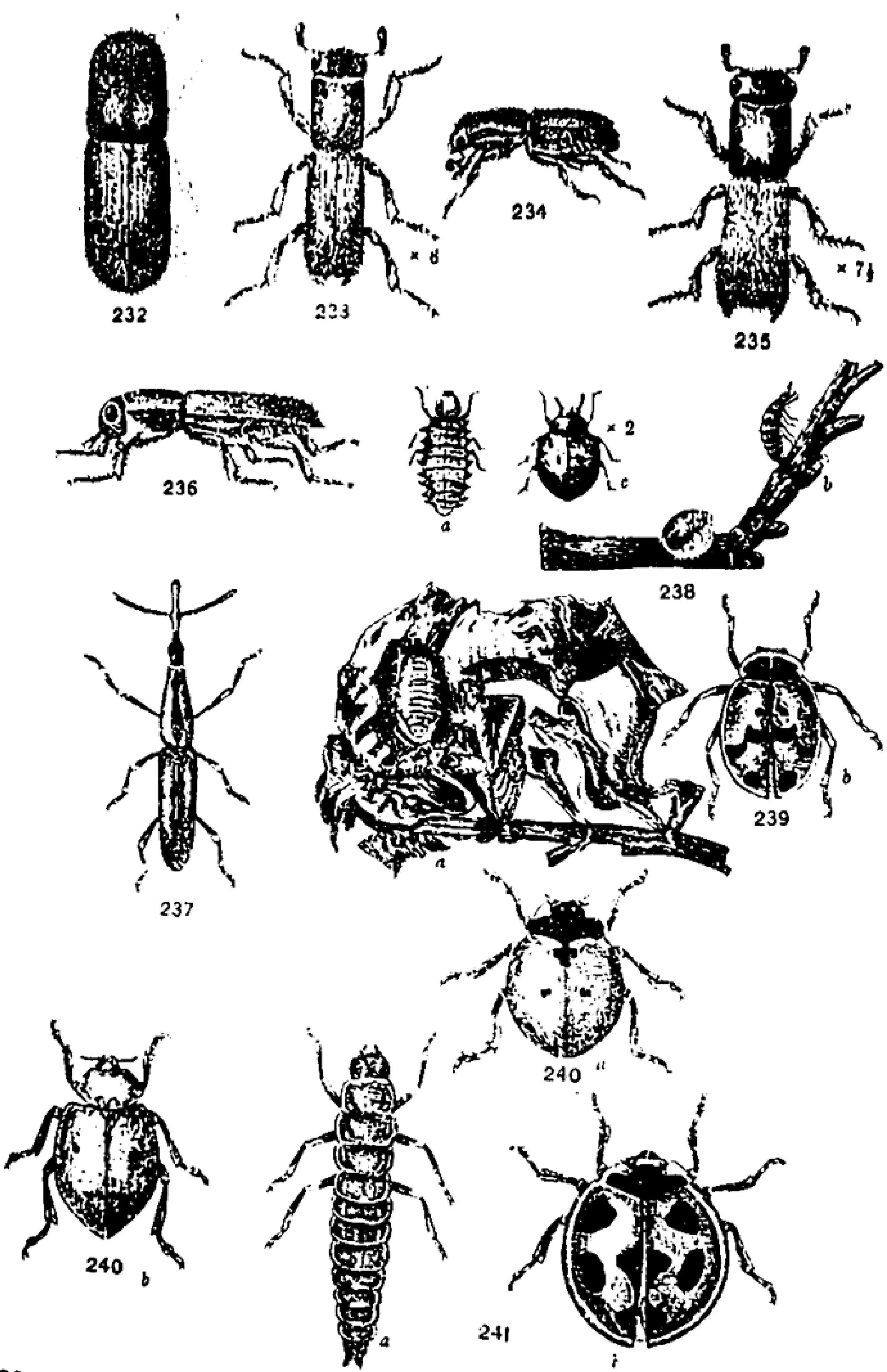
Life history of *Vedalia Guérinii.*

The life-history of this predaceous beetle is very simple. The female Monophlebus scale (see p. 164) first appears upon the leaves in the cold weather months, December and January. By the middle of March it is half-grown, having by then descended from the leaves to the twigs. The small active black or grey-coloured larvæ of the lady-bird beetle are then to be found running over the trees and feeding upon the scales. They suck the soft fat scale quite dry, leaving only a shrivelled skin. When feeding upon the coccid they attach themselves to the branch by means of a small sucker-pad arrangement they have at the end of their bodies. This attachment is so powerful that the scale, which is several times larger than the concinellid larva, is quite unable to drag the grub off and thus escape. Towards the end of March and on into April the larvæ begin to change into small crimson pupæ. In doing this they first attach themselves to a leaf or branch by the sucker-pad and remain projecting out at an angle from it. After 24 hours the skin splits down, shrivels back, and discloses the crimson pupa sessile on the leaf or branch. After 7 to 8 days the skin of the pupa splits down in front and the small red beetle crawls out. It is first covered with a white down. but soon lose this, and darkens to a dark red with six black spots upon the elytra. The beetle also feeds upon the scale. It pairs about the end of April and then lays eggs. The life-history for the rest of the year has not yet been studied. Fig 238a shows the larva, b, a larva commencing to pupate, and a pupa sessile on a branch and *c*, the beetle.

Other species of Coccinellidæ are *Hippodamia variegata* var. *Doubledayi* of which the pupa, in a twisted up peach leaf, and beetle are shown in fig. 239: it is predaceous upon the peach Aphis of the Dun; *Coccinella septempunctata* (fig. 240 *a*) which is of almost world-wide distribution; *Hippodamia constellata* (fig. 241*b*) which is predaceous upon the Himalayan *Chermes* pest, *Chermes abietis-piceae*; and *Cœlophora sauseti* also predaceous upon the peach Aphis of the Dun; fig. 24 *b* shows the larva and beetle of this latter insect.

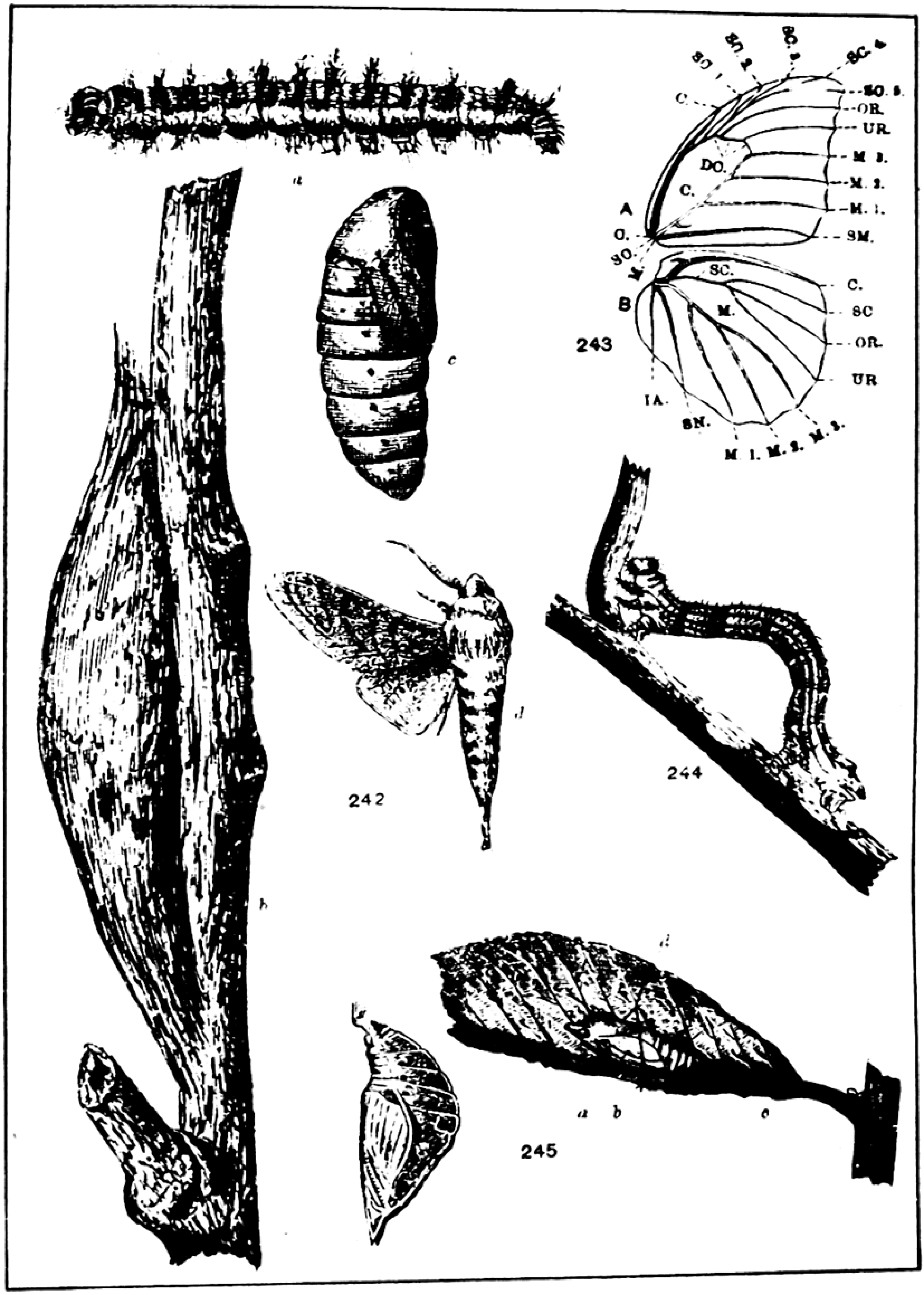
Useful Coleoptera.

The Lamellicorns include dung and other useful scavenger beetles, such as *Scarabæus.* Amongst the *Adephaga*, the *Cicindelidæ* and *Carabidæ* are useful preda-



232. *Xyleborus perforans.*
233. *Crossotarsus coniferæ.*
234. *Platypus sp.*
235. *Diapus talurœ.*
236. *Diapus heretieræ.*
237. *Brenthus sp.*
238. *Vedalia Guérinii.* a, larva; b, larva pupating and pupa on a branch; c, beetle.
239. *Hippodamia variegata.* a, pupa in rolled-up mass of peach leaves; b, beetle.
240. a, *Coccinella septempunctata;* b, *Hippodamia constellata.*
241. *Cœlophora Saussei.* a, larva; b, beetle.

ceous families containing many carnivorous forms. In the Clavicornia the *Silphidæ* include the useful carrion and burying beetles and the *Staphylindæ*, *Histeridæ* *Nitidulidæ*, and *Trogositidæ* containing numerous forms predaceous upon bark-boring and wood-boring pests. Under the Serricornia the larvæ of the *Malacodermidæ* are supposed to be predaceous and the family Cleridæ are likely to furnish the forester with several useful allies, *Thanasimus himalayensis*, described as feeding upon several scolytid pests, being of an inestimable value in the forest. Some of the *Elateridæ* larvæ may prove to be useful in this connection. The metallic coloured elytra of the *Buprestidæ* are used to some extent in Southern India for ornamentation purposes and also as caste marks, whilst the *Cantharidæ* contain beetles, such as the oil and blister beetles, which are used in medicine. Little is known at present about the *Brenthidæ* in India, but the family is known to include predaceous forms. The *Coccinellidæ* are likely to prove of very great value as the family contains many exclusively predaceous insects.



242. *Suana concolor.* *a*, larva ; *b*, cocoon on a Sál-tree branch ; *c*, pupa ; *d*, moth.

243. Diagram of the wings of a butterfly ; A, front ; B, hind wing ; C, costal ; SC, subcostal ; M, median ; SM and SN, submedian nervures ; IA, inner-margin nervure ; UR, lower radial ; OR, upper radial ; SC 1 to SC 5, divisions of subcostal ; M 1 to M 3, divisions of median nervure ; C, cell ; DC, disco-cellulars.

244. A looper caterpillar (*Biston suppressaria*).

Chapter VIII.

Order VI.—Lepidoptera.

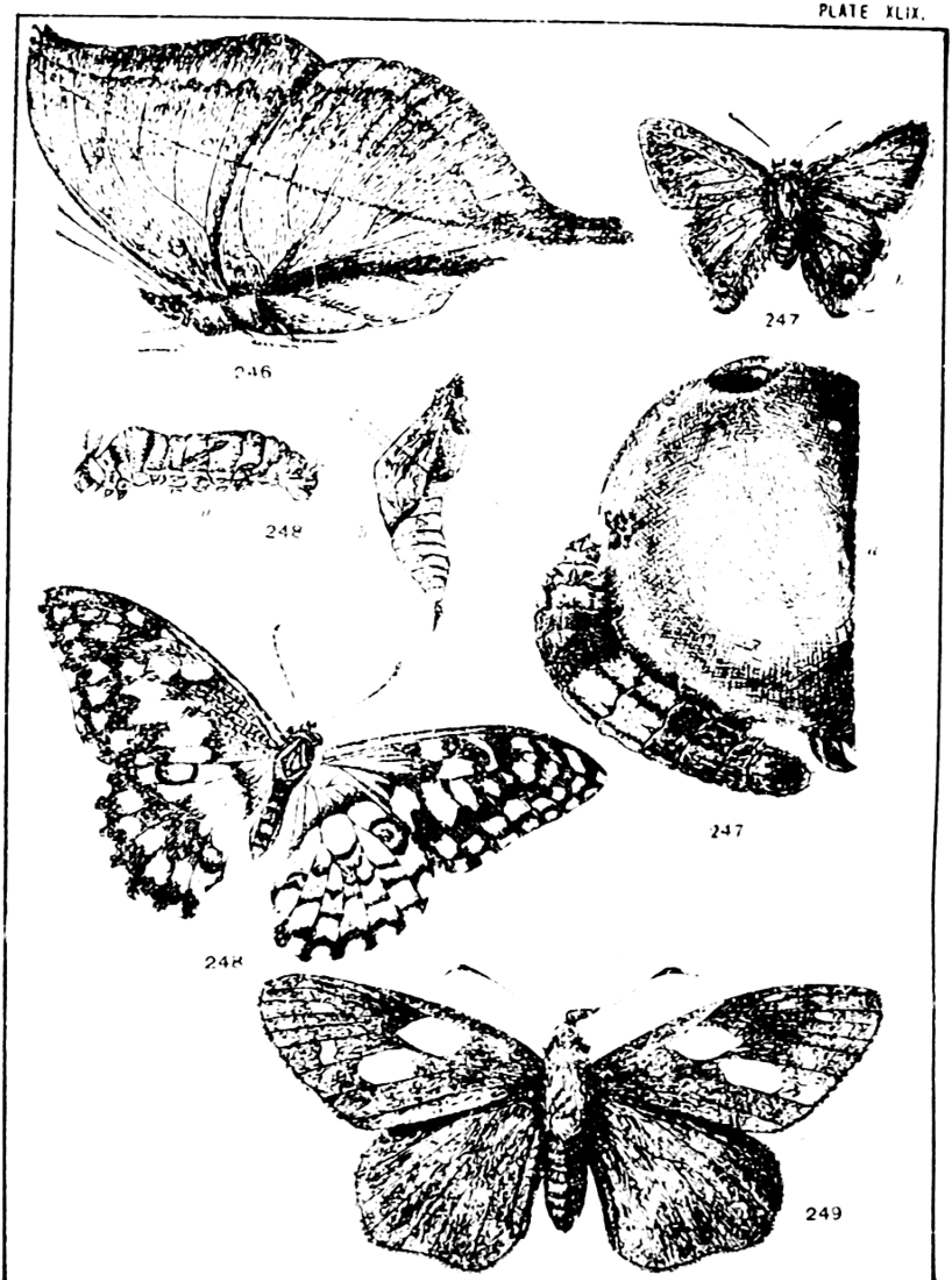
This order comprises the butterflies and moths, both of which are very numerous in India. They are provided usually with four wings, all of which, together with the body, are covered with coloured scales, those on the body looking more or less like hair. The mouth parts in the perfect insect are formed for sucking and are in the form of a coiled tube or proboscis. This proboscis is the characteristic feature of the mouth of a lepidopterous insect, and owing to the possession of such a mouth the destructive powers of the adults are very limited. The head is small with two large eyes, and ocelli may be present. The antennæ are simple and knobbed or pectinate. The prothorax is small. flat, and scale-like, and is attached to the other portions of the thorax The wings are various in shape, and the hind wing is sometimes prolonged into a tail The wing is divided for purposes of description into the following regions: inner angle, costa, outer angle, hind margin, anal angle, and inner margin fig. 24). The wings are always fringed with hairs. The legs are unusually long, slender, and weak, the tibiæ being furnished with spines In most moths the upper and lower wing is joined by a hook and loop arrangement, the loop being on the upper wing and the hook on the lower. This is never present in butterflies. Tarsi are five-jointed The abdomen is cylindrical and sometimes flattened on each side. The males differ from the females in being smaller, more brightly coloured, with a thinner body, more highly developed antennæ, and by having the body sometimes terminated in a clasping arrangement for catching hold of the female. The eggs are various in shape and are often very elaborately marked. Practically the only damage done by this order is committed in the larval stage. The larva (24*a*) has a cylindrical worm-like appearance. It consists of a well-marked head followed by twelve segments. The first three segments bear legs, which are jointed and horny, and are called thoracic legs; next there are two small segments with no legs, and then four segments bearing each a pair of sucker legs provided with small hooks for clinging to leaves, etc. These legs are called the abdominal legs; following these there are two more legless segments, and

the last segment bears a pair of clasping legs. Never more than eight pairs of legs are present in the Lepidoptera, though the number may be fewer and in this way caterpillars can always be distinguished from saw-fly (*Tenthredinidæ*) larvæ which greatly resemble them; the latter having always more than five pairs of clasping legs. In some caterpillars only the thoracic or pro-legs and the last pair of abdominal and clasping legs, are present (fig. 244). In a few cases the pair of clasping legs is absent. The head is furnished with a few ocelli placed just above the mouth. The antennæ are short and three-jointed. The larva is sometimes provided with silk, and there are then two small glands at the sides of the body, the silk coming from these in the form of two separate threads, which become glued together by a cement which hardens in the air; the larvæ suspend themselves by this thread. There are nine pairs of spiracles (breathing openings) present, situated at the sides of the 2, 5, 6, 7, 8, 9, 10, and 11 segments (fig. 250 B, a). The anus is covered by a triangular flap. The larva is covered with hairs which may be few and small, or long and numerous; these spring from tubercles situated on the skin. Whilst developing the caterpillar passes through a series of moults, 2—5 in number, but usually 4, during which it may change considerably both in form and colour.

The larva pupates either by burying itself in the ground hanging itself up by its tail, making a silken cocoon, or external covering, and changing to a chrysalis within this (*cf.* figs. 242, 245), rolling up the edges of a leaf and pupating inside (fig. 268), etc. The pupa is covered by a continuous skin which only shows the outline of the antennæ proboscis, eyes, folded wings and limbs of the future insect and the divisions of the abdomen below. The proboscis may project a long way in some cases as in the Hawk Moths. When the insect is mature it bursts the skin and crawls out. The wings at this stage are very small and soft and crumpled up. After leaving the pupal skin the perfect insect hangs itself up head uppermost, and pumps fluids from its body into the wings so as to expand them. This process never takes more than two hours, by the end of which period the wings are fully expanded and hardened and are ready to be used for flight.

The length of the life cycle of insects of this order may vary from two weeks or less to over four years. In the latter case the greater part of the time is passed in the larval or destructive period

PLATE XLIX.



246. *Kallima butterfly.*

247. *Virachola isocrates.* *a*, larva feeding upon pomegranate (Lefroy); *b*, butterfly.

248 *Papilio demoleus.* *a*, larva; *b*, pupa; *c*, butterfly.

249. *Gangara thyrsis.*

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of their life ; this is important in the case of the wood-boring members of the order as it greatly increases their power of committing damage. Mimicry and protective resemblance is very marked amongst the Lepidoptera, and cases are frequent where a harmless insect assumes the shape, colouration, and markings of the noxious one in order to escape the attacks of its bird and insect foes. For instance, members of the genus Papilio often mimic the colouration of noxious Danaids.

The Lepidoptera are divided into the two series of RHOPALOCERA or Butterflies and HETEROCERA or Moths.

Series.—RHOPALOCERA or Butterflies.—Antennæ knobbed at the tip or thickened a little before the tip, without pectinations or projecting processes. Hind wings without a frenulum (the one or more stiff bristles projecting forwards and outwards from the inner upper angle of the hind wing are called the frenulum), but with the costal nervure strongly curved. The insects are diurnal in habits. Larva has always 16 legs.

Series.—HETEROCERA or Moths.—Antennæ vary in form, generally pectinate, only rarely knobbed at tips, and then a frenulum is present, and the costal nervure is either not arched at the base or there is a large margin both between it and the front margin. Larva may have less than 16 legs.

Rhopalocera (Butterflies).

Are of little importance in forestry as far as is at present known. They may be divided into the following four groups:—

(i) Includes the majority of butterflies. The first pair of legs are modified, being generally smaller than the others and not used for walking; the tarsus often does not consist of a succession of simple joints as is usually the case with insects. There is no pad on the front tibia. The chrysalis is naked and is suspended by its tail to the food plant or is girt round the centre with a silken cord. The families included in this group are the *Nymphalidæ* [to which the leaf-butterfly (*Kallima*) (fig. 246) belongs], *Erycinidæ* and *Lycænidæ* (to which the Blues and Coppers

belong). The Lycænid, *Virachola isocrates*, is a common little violet blue or brown butterfly of the plains of India (fig. 247). The blackish-brown larva feeds in the fruit of pomegranates, loquat, guava, etc.

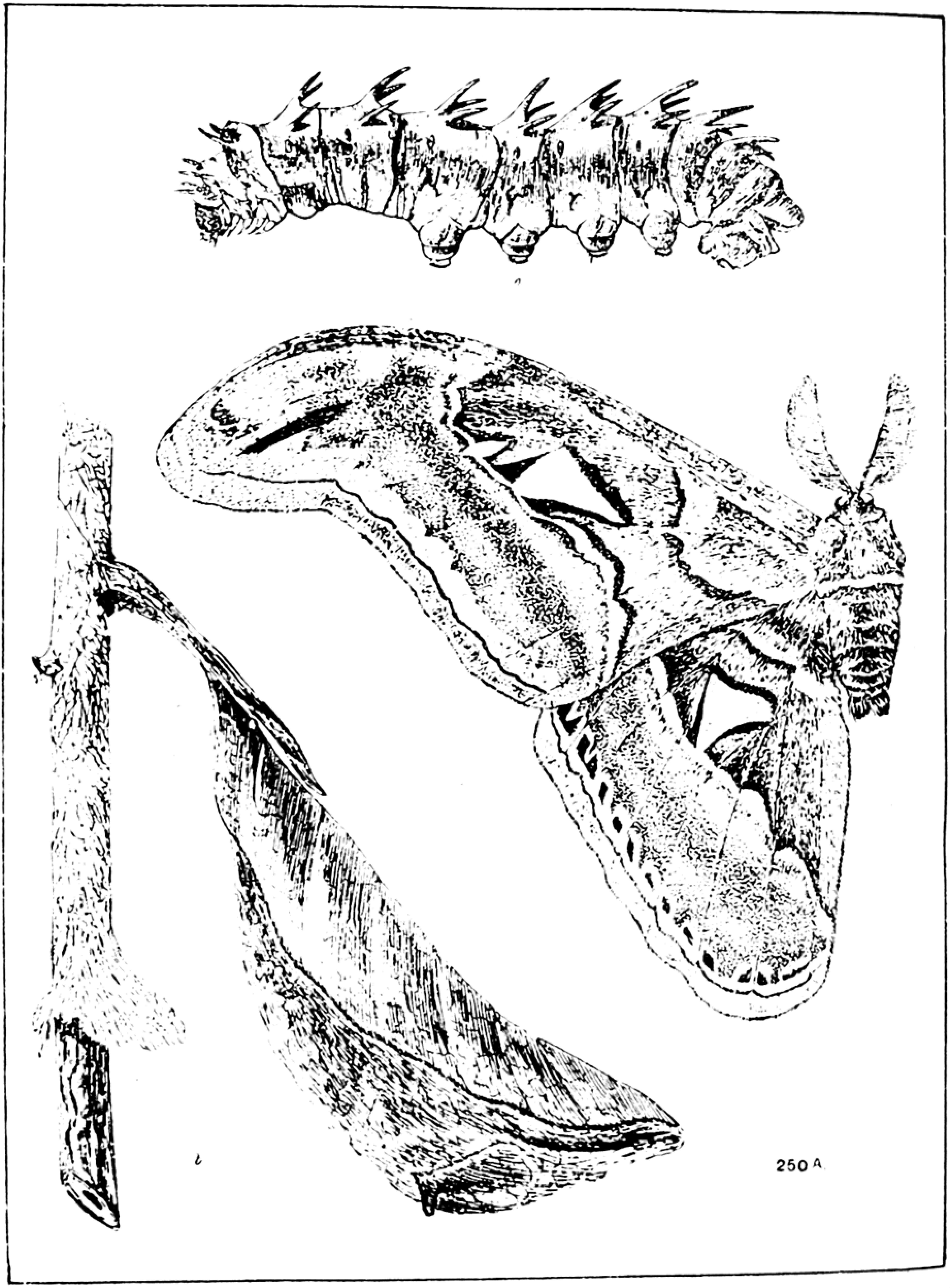
(ii) The front legs are similar in form to the others; their tibiæ have no pads; the claws of all the feet are bifid. The pupa is attached to the food plant by a silken cord girt round about its centre. The group includes the *Pieridæ* containing the Whites, Brimstones, Clouded Yellows, etc.

(iii) The front legs are like the other pairs; their tibiæ, however, possess pads, the claws are large and not bifid. The pupa is naked and tied to the food plant by means of a silken cord round it. The family *Papilionidæ*, consisting of the swallow-tail butterflies, comes here. Fig. 248 shows the larva, pupa and butterfly of *Papilio demoleus*. The insect defoliates citrus plants, bael, and *Zizyphus jujuba*. The larva mimics bird droppings when young.

(iv) The front legs are like the other pairs; their tibiæ possess pads, the claws are small, toothed at the base, and there is a hook at the end of the club of the antennæ. The chrysalis is rolled up in a leaf or other covering. The family *Hesperiidæ* or skippers are included here. The caterpillars of the hesperid *Gangara thyrsis* (fig. 249) are very destructive to young cocoanut trees in North Malabar.

Heterocera (Moths).

The series Heterocera or Moths is a most important one in forestry. Next perhaps to the great order *Coleoptera* the moths contain some of the most dangerous pests the forester has to deal with. Both as defoliators, wood-borers, shoot miners, and seed destroyers, these insects are to be found at work in the forest, and the destruction caused is sometimes on a very large scale. The trees in whole forests, districts, or even provinces, are at times completely defoliated owing to sudden and large increases in the numbers of caterpillars, whilst entire seed crops of valuable species may be ruined by members of the series. The following families are considered. It is probable



250a. The Atlas Moth (*Attacus Atlas*). *a*, larva; *b*, leaf bound together with silk forming the cocoon in which the pupa is enclosed; *c*, moth.

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that others, at present considered unimportant, will, as our knowledge increases, need inclusion.

FAMILY I.—*Saturniidæ.*

Large insects which vary a great deal; the moths have no frenulum and no proboscis; the hind wings have a large shoulder so that the anterior margin extends a long way up beneath the front wing as in butterflies. The wings often have transparent spaces resembling windows in them. The antennæ in the males are strongly bi-pectinate and are often very highly developed. The larvæ construct cocoons, the products of several species being used as silk. These cocoons vary greatly from a loose open net-work to a continuous, entirely closed chamber. The family contains some of the largest members of the insect world. The larvæ feed on the foliage of forest trees.

A well-known representative of this family is the moth, Attacus Atlas, an enormous insect with a large transparent window in each wing. The caterpillar is pale olive green and lavender (fig. 250 A), and has a peculiar conspicuous red mark on each flank, close to the clasper. It is covered with prominent tubercles and fleshy spines.

FAMILY II.—*Bombycidæ* (True Silk-worm Moths).

Largish moths with stout woolly bodies, with no proboscis and no frenulum to the wings. Antennæ are short and are feathered in the males. The larvæ are hairy and are gregarious. The pupa is formed within a silk cocoon, the silk of which has often a commercial value.

There are several important species in the family. The domesticated mulberry and *eri* silk-worms and the semi-domesticated *tusser* and *muga* silk-worms are worthy of note. In addition there are a number of wild silk-worms in India whose silk is very good and would be extremely valuable were it forthcoming in larger quantities. Several varieties of the mulberry silk-worm, *Bombyx mori*, are cultivated in the plains of Bengal upon mulberry leaves, and a large amount of valuable silk is obtained from them annually.

The insect suffers considerably from Tachnid fly and other parasites. The *eri* silk-worm, *Attacus ricini*, is reared in Assam on castor oil leaves. It has several generations in the year (as also has *B. mori* in India), and the silk produced is the well-known coarse Assam silk. In the forest the most important silk-worms are the *tusser* and *muga*.

Life history of the *Tusser Moth.*

The larva of the *Tusser* (*Antheræa mylitta*) is a brilliant green adorned with numerous tubercles. The moth is a large yellow or buff coloured insect, which can be recognised by its shape, size, and the curious transparent glass window-like patches in its wings. The cocoon is large, hard and is attached to the food plant by a silken stalk of great strength. Fig 251 shows larva, pupa, and moth of *A. mylitta*. This insect is reared in the forests of the Central Provinces, Chota Nagpur, and elsewhere throughout the central and southern parts of India. The caterpillars feed upon the leaves of *Terminalia tomentosa*, sál, *Zizyphus Jujuba*, etc. The insect hibernates through the winter in the cocoon. The moths of the first generation emerge at the beginning of the rains (June) and lay eggs from which cocoons are obtained about the middle of the wet season. Moths issuing from these lay eggs immediately. These eggs hatch out at once, and the caterpillars pupate about the beginning of the cold weather. (October-November). Fresh cocoons for breeding are generally collected each March in the forest when the foliage is thin, and they can be easily discerned. These are tied on to the trees, the latter being pollarded.

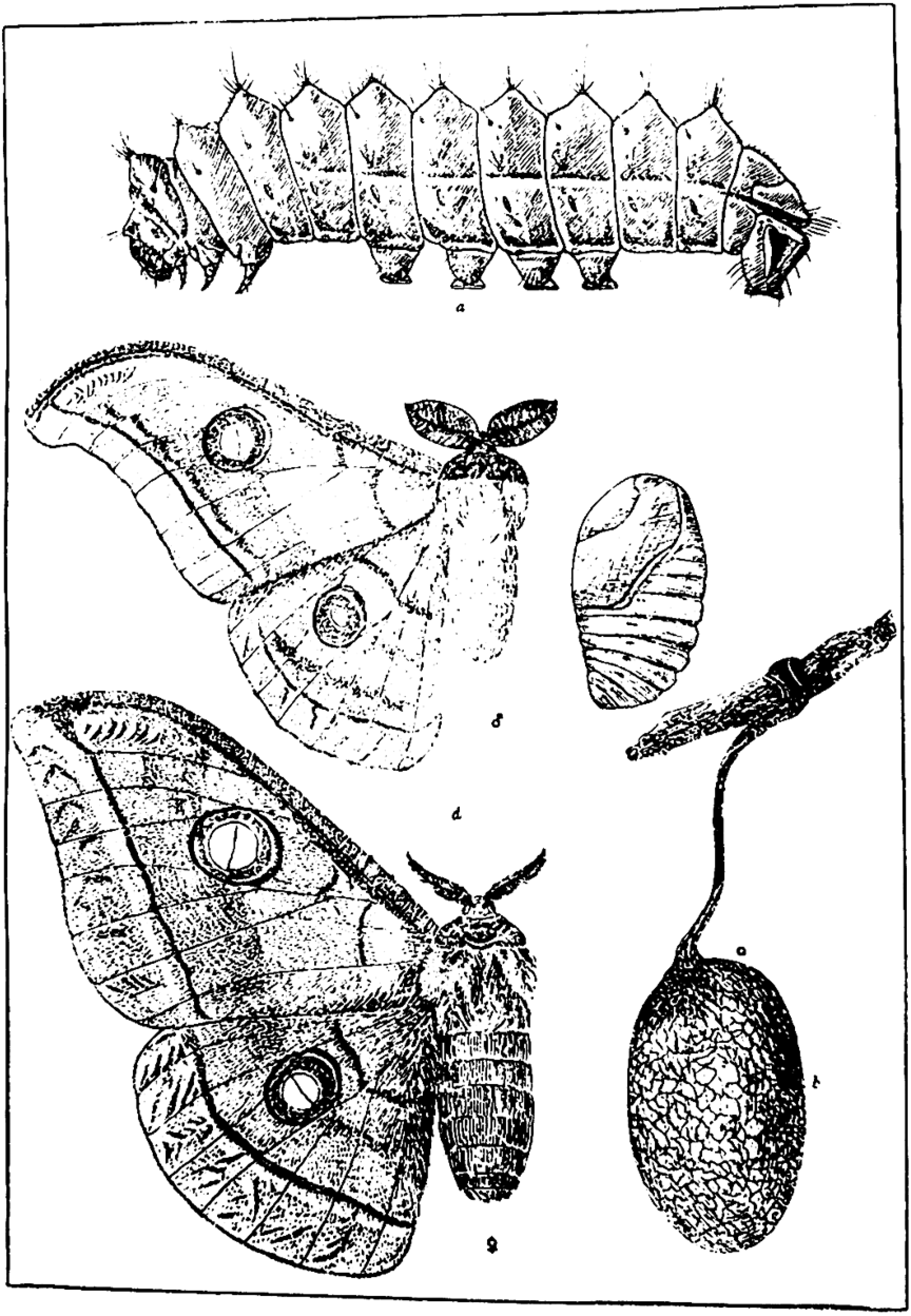
The *Muga* (*Antheræa assama*) is reared in Assam in much the same way as the Tusser in Chota Nagpur as above described. The cocoon has no stalk, and the silk has a beautiful golden sheen. The insect is reared upon *Machilus odoratissima, Tetranthera monopetala*, etc.

Forest revenue is obtained in various parts of India from these insects, and it is not at all improbable that, if the experiment were carefully conducted, their introduction might be possible into poor areas of forest growth in parts of the country where they are not at present found.

This family includes a pest of the *Ficus elastica*, a moth named *Gunda sikkima* whose caterpillar feeds upon the leaves of the India-rubber tree. The caterpillar is greenish-yellow in colour, and when full fed spins a white silk cocoon to the underside of the leaf. The moth is a medium sized one of the silkworm type, the female being larger than the male. Fig. 251 shows the moth. In October 1905 the larva of this insect completely defoliated several compartments of the Chardnar Rubber Plantation in Darrang, Assam. The caterpillar also feeds upon the *pipal* tree.

FAMILY III.—*Eupterotidæ*.

Small hairy moths resembling the Lasiocampidæ (*vide infra*), but the wings possess a frenulum, the larvæ are hairy, and these hairs often produce great irritation to the skin. The caterpillars are sometimes social in their habits and live together in dense webs on trees and plants or march about in processions, when they are called "processionary caterpillars." Those living in dense webs on the other hand are called "tent caterpillars."



260B. *Antheræa mylitta*. The Tusser Silkworm. *a*, larva ; *b*, cocoon fastened to a twig ; *c*, pupa taken out of the cocoon ; *d*, male and female moths.

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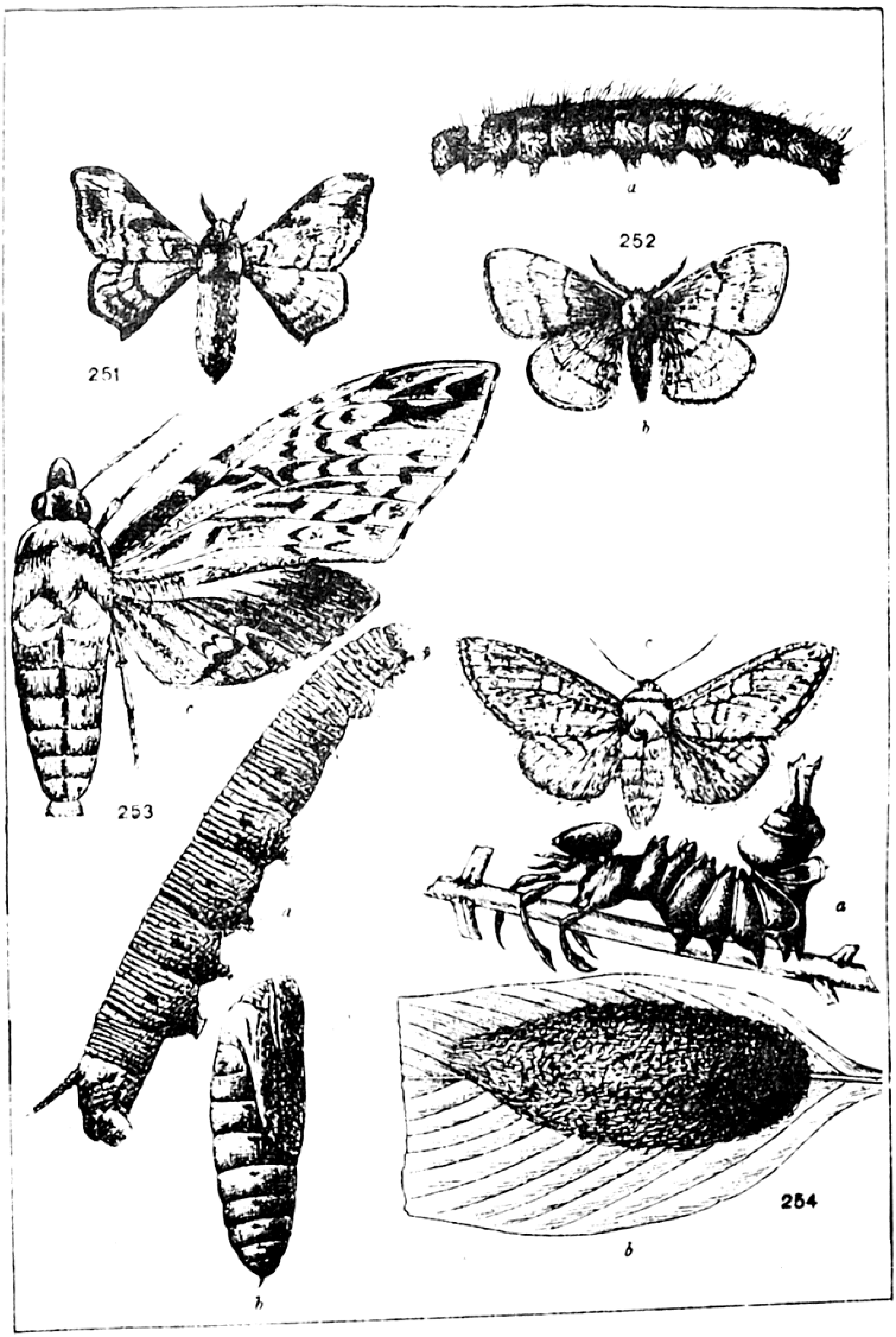

251. *Gunda sikkima.*

252. *Euteropte minor.* a, larva ; b, moth.

253. *Pseudosphinx discistriga.* a, larva ; b, pupa ; c, moth.

254. *Stauropus alternus.* a, larva in characteristic position of rest ; b, cocoon on leaf ; c, moth.

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Processionary caterpillars are not uncommon in India. Two instances of the annoyance they cause may be mentioned. In 1891 a plague of hairy caterpillars appeared in Shwebo, Burma, and covered the country, eating all herbage and swarming on roads and in buildings in enormous numbers; their hairs produced irritation and even sores on the skin. Moths obtained from these caterpillars were identified as *Eupterote minor*. Fig. 252 shows the larva and moth.

This family is therefore dangerous to man in a two fold manner. Firstly owing to the actual defoliation damage they are capable of doing; and, secondly, owing to the fact that when they swarm they become a veritable plague to man, bad sores resulting from the irritating properties of the hairs. Their dead bodies also choke up drains, etc., giving rise to noxious effluvias which are liable to produce pestilence, and in this way they resemble that scourge, the North-West locust.

Of tent caterpillars a species lives in dense web tents on the *Semicarpus anacardium* in the North Coimbatore forests. The larvæ apparently issue from the tent at night and completely defoliate the tree.

FAMILY IV.—*Sphingidæ* (HAWK-MOTHS).

Moths of large or moderate size with frequently a very long proboscis and provided with a frenulum on the long, narrow wings. Bodies stout and often torpedo shaped. Antennæ are short and stiff, ending in a hook at the tip. The larva is large and fleshy and generally remarkably coloured and is provided with a horn on the dorsal surface of the eleventh segment and has sixteen legs. The caterpillars do not spin cocoons, but bury themselves in the earth. In the pupa the proboscis sometimes projects on the breast like the handle of a pitcher.

The caterpillars of these moths feed upon vegetation, generally living upon the leaves of trees or shrubs. They are usually by no means plentiful.

Life-history of Pseudosphinx discistriga.

A species, named *Pseudosphinx discistriga*, defoliates the teak in the Melghat Forest in Berar. It is bright-green in colour changing to dark yellow-green on maturing. In July 1901 it existed in considerable numbers on the trees, and a fairly large amount of defoliation had been occasioned by it. The same larva was also found in the Central Nursery at Poona, and it may prove to be general throughout the Bombay and Central India teak forests. The moth issues about the beginning of August, and the pupal stage is probably a short one.* The rest of the life-history has not yet been worked out, but the case is an interesting one since the hawk moth

* For further information on this insect: *vide* Departmental Notes on Insects that affect forestry, Vol 1, p. 52, Plate II, Fig. 1.

larvæ are not usually to be found feeding gregariously together. Fig. 253 shows the larva, pupa, and moth of this insect.

FAMILY V.—*Notodontidæ* (Prominents, Puss Moths).

Obscure coloured moths with at times elongate bodies terminating in long large tufts of coloured hair (scales). The larvæ are often very remarkable objects.

The Lobster caterpillar of India (fig. 254a) is, perhaps, one of the most remarkable. It has exceptionally long thoracic legs, the abdomen is swollen at the tip, and instead of the terminal claspers it has two long slender processes. These peculiarities are greatly enhanced by the curious attitude taken up by the larva, the first five segments being held erect with the second and third pairs of thoracic legs outstretched; the swollen terminal segment is also held erect. This peculiar method of holding itself is probably maintained to protect the larva from predaceous and parasitic foes. It has proved itself a serious pest to the tea plant, more especially in Ceylon, where it swarmed in numbers in 1902-3. It has also been reported as defoliating the cocoa plant and not improbably feeds upon the foliage of forest trees. Fig. 254 shows the larva, cocoon on a leaf and moth.

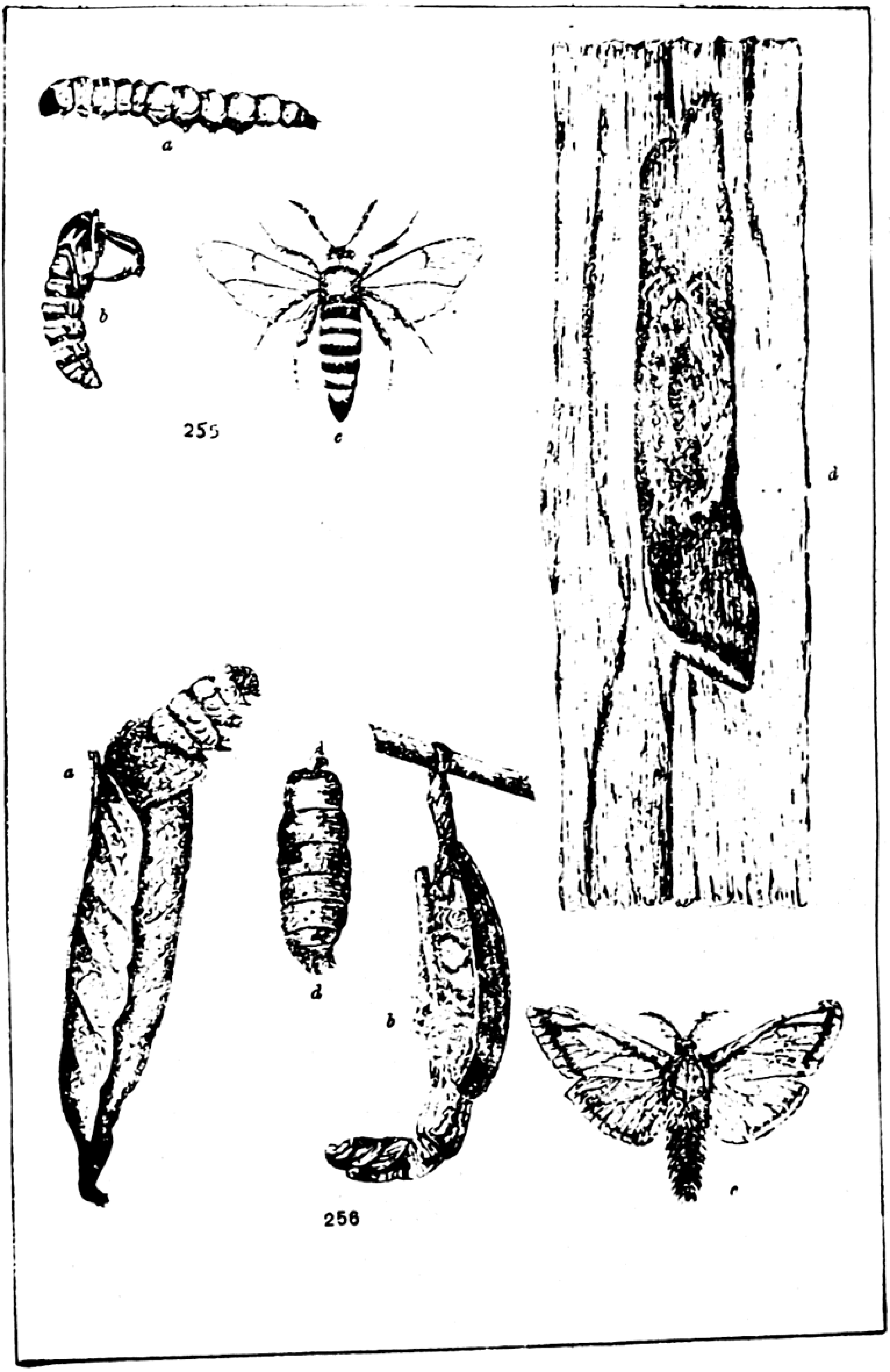
FAMILY VI.—*Sessiide or Ægeriidæ* (Clear-wings).

A comparatively small family of moths whose wings are without scales; the tip of the body is tufted, and the insects resemble wasps to a great extent. The larva is nearly naked and colourless and thus resembles a longicorn grub. It can be distinguished, however, by the fact of its having 16 legs. The larvæ feed in wood and do damage to trees in this way. They invariably feed concealed in stems, branches, etc. The pupa is furnished with a row of spines on the segments of the abdomen.

Life-history of Trochilium omnatiæforme.

The Baluchistan poplar-borer, *Trochilium omnatiæforme*, is an insect belonging to this family. The eggs are probably laid in the bark of the tree attacked during October and November, the caterpillars hatching out either immediately, or more probably, in the ensuing spring. As soon as hatched they bore through the bark. In April, when about half grown, they may be found between the bark and the wood. From this time onward they commence boring straight into the heart-wood and remain tunnelling in this until September. The larva changes into a pupa in its burrow * inside a cocoon formed of wood chips placed near the exit hole, which is previously eaten out by the larva. The adult insect appears in October. It greatly resembles in appearance the small Indian wasp (*Vespa cincta*). Fig. 255 a-d shows

* For a further account *vide Injurious Insects*, pp. 95-98, Figs. 62, 63, 64.



255. Baluchistan Poplar-Borer (*Trochilium omnalıæforme*). *a*, larva; *b*, pupa; *c*, moth; *d*, piece of poplar stem showing the cocoon in a larval tunnel.

256. The Sal Bag-worm (*Clania variegata*). *a*, larval case made of Sâl leaves with larva projecting from it; *b*, empty pupal skin of male moth projecting from the larval case or bag; *c*, male moth; *d*, wingless female moth.

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the larva, pupa, moth, and a piece of stem of poplar tunnelled by this pest. In 1890 the poplar trees (? *Populus euphratica*) suffered severely in Baluchistan from this insect. The trees were grown from cuttings, and when about two years old they were attacked by the larvæ. The eggs must have been laid on the bark near the ground, and the caterpillars on hatching out bored through the trunk and riddled the wood in all directions, the stems being generally killed off before they reached the age of five years. The roots were not attacked, and therefrom fresh shoots came up in the majority of cases, the loss experienced being the putting back of the plantation by several years.

FAMILY VII.—*Psychidæ* (Bagworms.).

Small or moderate sized moths with imperfect scales and dusky in colour; the sexes are very different, the female being wingless and sometimes quite maggot-like; the male often has bi-pectinate antennæ, the branches of which are sometimes very long and flexible. The larva soon after hatching forms for itself a case of pieces of sticks, leaves, etc., in which it lives, carrying it about on its back like a snail in its shell. This case is always present, and the wingless female moth never leaves it. Fig. 256a shows the larval case of *Clania variegata;* it is made up of pieces of sál leaves externally lined with silk internally. The larvæ do damage as defoliators.

Life history of Clania variegata.

A species of this family, *Clania variegata*, defoliates the sál tree in the Duars in Bengal and also in Assam. The female lays her eggs about the beginning of March, within the pupal shell inside the case. After laying these eggs her abdomen becomes much reduced in size, and she drops out of the case and dies. The eggs are smooth yellow ovals, from which larvæ hatch out at the beginning of April. This is the first brood of the year, and several others follow it through the hot weather and rains. Three to four days after hatching out the young larvæ begin to construct their cases with pieces of moss and bark of sál trees, etc., and they feed upon the young new sál leaves. The mouth of the case is made flexible so that the larva can draw in its head for protective purposes. As it grows older the larva feeds upon the older leaves of the tree. When about to change to the pupal state the case is fastened to a twig or to the bark and the mouth of the case is then closed. The larva then proceeds to cover the inside of the case with a fine loose silk, and turning round hangs head downwards inside and changes to a pupa. In emerging the male cuts its way out of the cocoon by means of its sharp edged beak, a portion of the empty pupal skin being often seen projecting from the case. It has highly pectinated antennæ, and is about two-and-a-half inches across the wings. The female has some means of attracting the male to her, and pairing takes place by the

male projecting the end of his abdomen down into the case, which latter the female, being, as mentioned above, practically wingless, never leaves.

This insect was abundant and committed a certain amount of defoliation to the sál in the Guma Reserve in Goalpara (Assam) in May 1906. Fig. 256 a, b, c, shows larva in case, empty pupal case projecting from the case, and male moth; fig. d, the wingless female moth.

The larvæ of another member of the family, *Clania crameri*, feed upon the needles of the *Pinus longifolia* in the North-West Himalayas. The caterpillars hatch out in July and at once commence to feed upon the needles of the pine, from which, together with pieces of the twigs, they construct their cases. They remain feeding upon the trees until November. The winter is passed either in the larval or semi-pupal state. Perfect pupæ are to be found within the cases in April of the year succeeding that in which the defoliation took place. The moth appears in June.* This insect occasionally does a great deal of damage (markedly so in 1898) to the *P. longifolia* by entirely stripping the trees of their needles; such attacks, in the weakened condition of the tree, are usually followed by the appearance of the *Polygraphus longifolia* and *Cryphalus*† bark-borers which complete the destruction of the tree (*vide* p. 110, *ante*).

Life history of Clania Crameri.

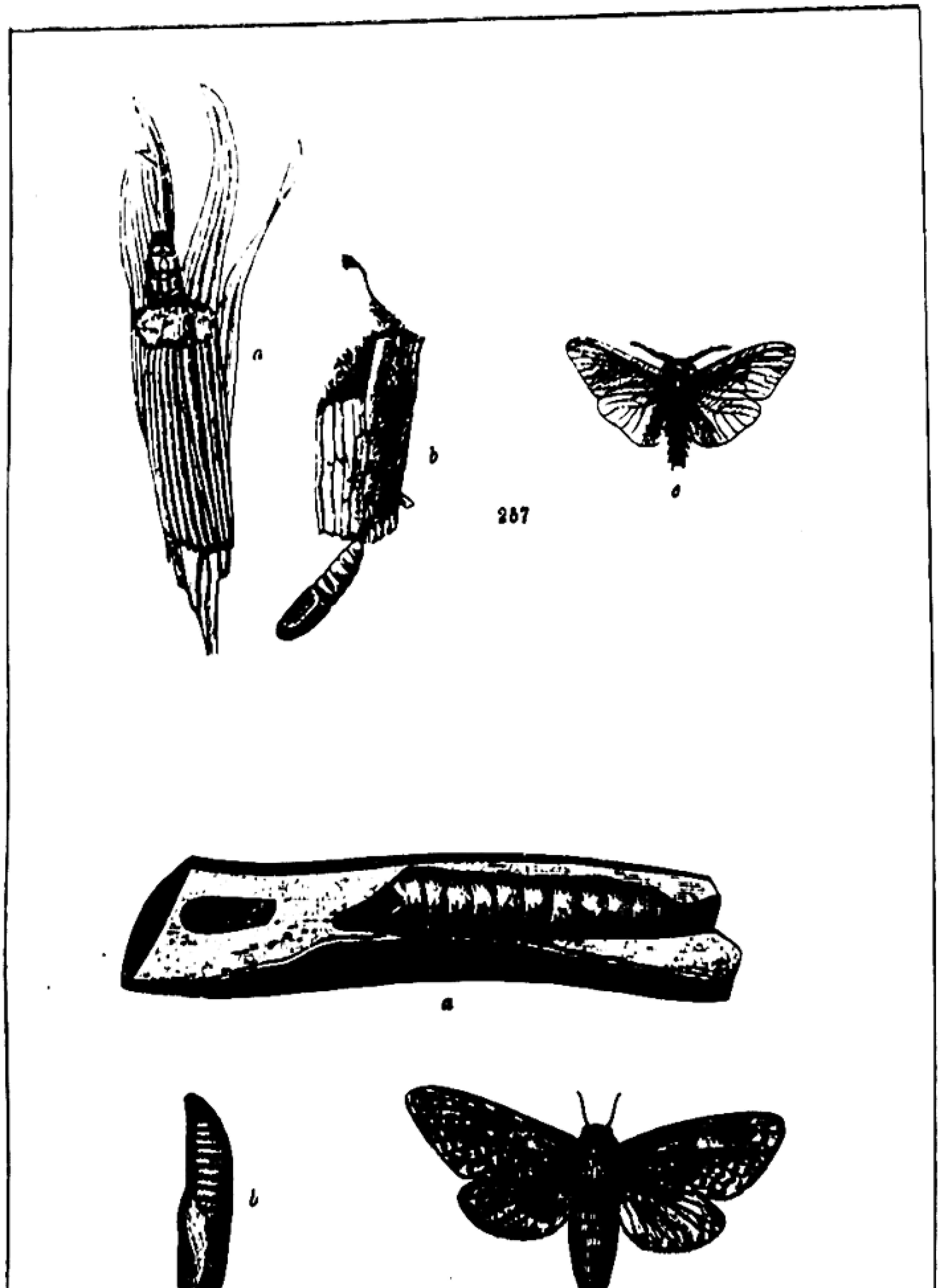
The caterpillars of this moth also feed upon and defoliate the Casuarina plantations in Ganjam and elsewhere on the east coast of Madras. The insect here passes through at least two generations in the year, caterpillars appearing upon the tree in April or May and again in August-September. The larvæ of the first generation pupate in July, the pupal stage lasting a fortnight. The ♂ moths on issuing pair with the ♀ in the case. The ♀ lays between 550 and 600 eggs in the case. These eggs hatch within a week of being laid. The young larvæ commence to make the first case within 20 hours of hatching, using the epidermis of the bark. It is only later on that the needles are used in completing the case. These caterpillars pupate towards the end of October and in November, the winter being passed in this stage.‡ Fig. 257 show the larva, empty pupal skin and male moth.

As the larvæ of this family usually form their cases of dried twigs, moss, grass, straw, leaves, etc., they are generally often very difficult to see when amidst their natural surroundings, and it is probably due to this that at present so few species have been reported as doing damage in the forest. Many species are known to feed entirely upon the leaves of woody growths (trees or shrubs), and the cases constructed are remarkable for their ingenuity and variety.

* *Vide* Departmental Notes on Insects that affect Forestry, Vol. I, pp. 56-57, and Plate II, Fig. 2 *a b, c*.

† *Vide* Departmental Notes on Insects that affect Forestry, Vol. I, pp. 255-257 267-273.

‡ *Vide* the Casnarina insect pest of Madras—*Indian Forester*, XXIX, Appendix Series.



257. *Clania crameri.* *a*, larva in case made of pine needles; *b*, pupa projecting from case; *c*, male moth.

260. *Zeuzera coffeæ* *a*, larva in tunnel in branch; *b*, pupa; *c*, moth.

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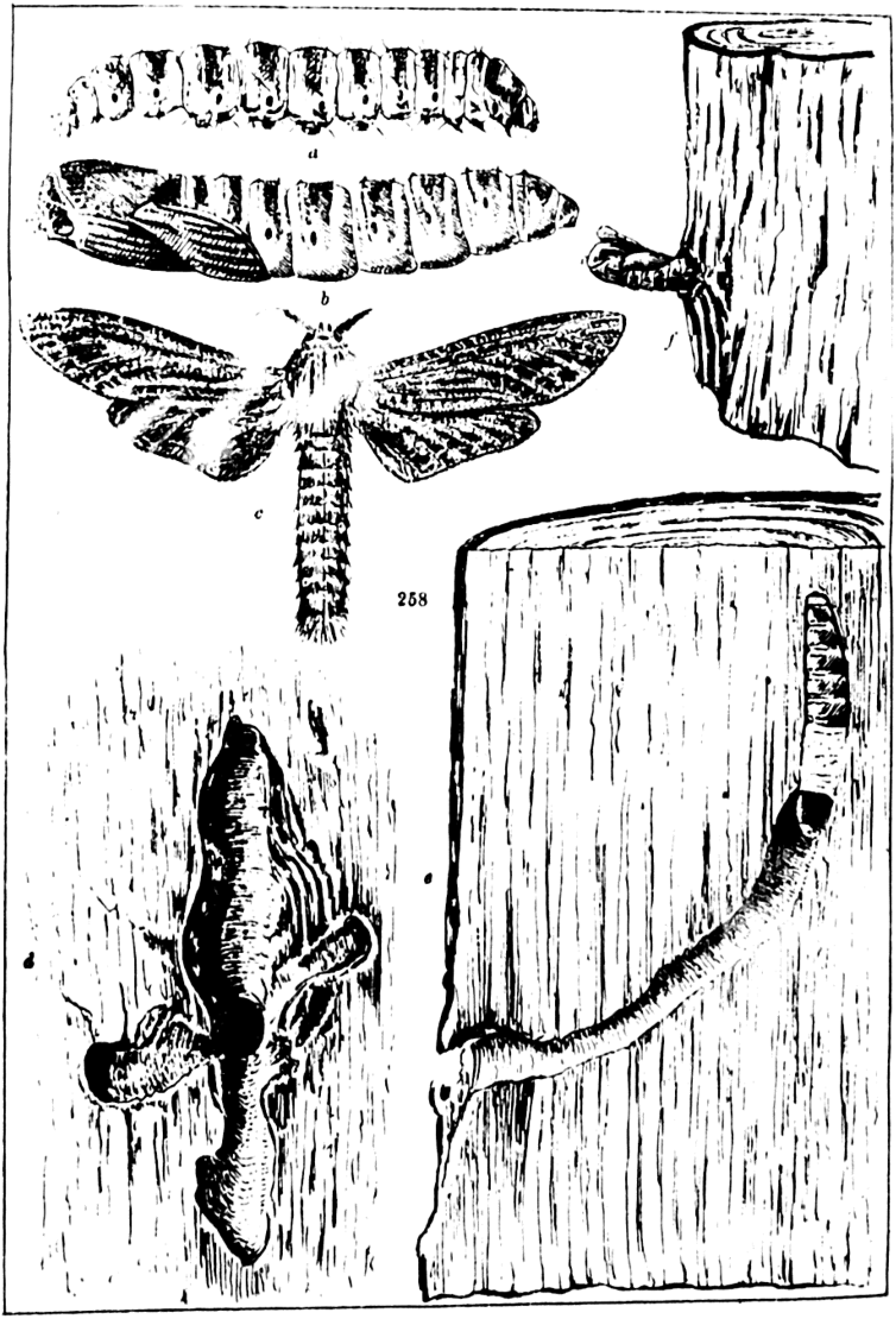

258. *Duomitus ceramicus.* The 'Bee-hole' Borer of Teak.
a, b, c, larva, pupa and moth ; *d,* bark and sap wood eaten out by larva ; *e,* pupa at end of the 'bee-hole' made in wood by larva ; *f,* empty pupal case projecting from bark of trunk.

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FAMILY VIII.—*Cossidæ* (Carpenter-worms).

The Cossids are moths of large size having no proboscis. They have frequently a dense covering of matted, imperfect scales on their wings, the pattern being vague. The larvæ are often large, are nearly bare of hairs, and have often very bright markings. They bore into trees, often making large ramifying burrows, and boring holes to the exterior from which the sap exudes and runs down the bark outside, serving as an indication of their presence. These larvæ often attain a length of several inches and may live for several years in this condition, mining up and down in the wood of the tree. The pupa is formed within a slight cocoon of silk mixed with gnawed wood. It is furnished with spines along the dorsal surface of the abdomen, by means of which it can move to a certain extent up the tunnel.

This family requires serious study in Indian forests. One or two pests are already known, and it will not improbably be found that others are a serious menace to young saplings, attacking and riddling them before they have grown to a size sufficient to escape damage.

Life-history of the 'bee-hole' borer of teak.

The genus *Duomitus* contains some of the largest insects of this family, many of them reaching a great size. The most dangerous pest at present known in the family is the insect which has been known for a number of years as the 'bee-hole' borer of teak in Burma. Quite recently it has been discovered that the cause of the 'bee-holes' in the timber is the caterpillar of *Duomitus ceramicus*. The eggs are laid upon the bark of the trees, both saplings and trees of considerable size being infested. The larva on hatching feeds in the cambium tissue and sap wood, eating out an irregular shaped patch. When full grown it is satiny white in colour with transverse dorsal pink stripes; it bores into the heart-wood eating out a tunnel about nine inches in length. This tunnel is always carried slightly upwards. The larva closes it by spinning over the mouth and at the upper end of the pupal chamber a strong web of coarse strands. On becoming mature the pupa cuts through the strands, wriggles down the tunnel, and projects from the tree (fig 258c) enabling the moth, which is brownish in colour, to escape. The tree is not necessarily killed by this attack, but the tunnels in the wood become covered over with later layers of wood, and thus the timber of an apparently sound tree may prove to be full of "bee-holes." Fig 258 a shows the larva; b, pupa; c, d, moth; e, attacks of larva in bast layer; f, 'bee-hole in timber with larva *in situ*.

Life-history of *Duomitus leuconotus*.

The larvæ of *Duomitus leuconotus* bore into and feed in the wood of *Cassia nodosa*. The eggs are laid on the bark of the tree by the female moth and the grubs on hatching out bore through the bark into the sap wood. When their mandibles are sufficiently developed they tunnel right into the heart-wood of the

tree, more than a year being spent in the larval stage. They are bright orange yellow in colour. The pupal stage is probably only a few weeks in duration Before pupating the larva takes its tunnel to the outside of the tree and then, backing down it, spins across it a stout covering of coarse hairs and silk; when the moth is ready to emerge the pupa wriggles up the tunnel and projects for nearly half its length from the mouth. The top then splits down, and the moth crawls out. The moth is a large, stout striking insect with a white thorax and greyish mottled wings. Fig. 259 shows the larva (half grown), pupa, moth, empty pupal case projecting from a tunnel and portion of an attacked stem.

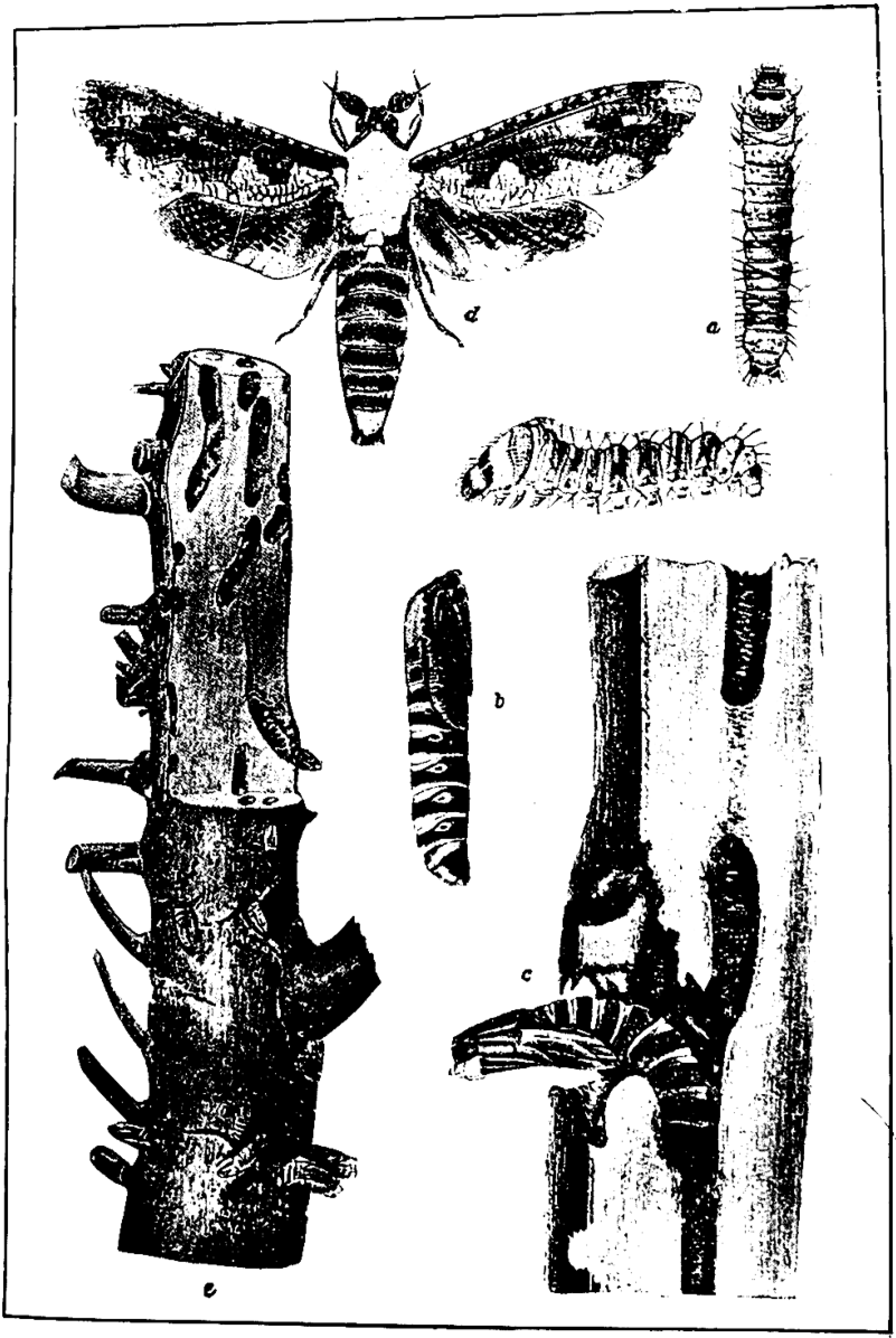
Cossus cadambe has been reported as attacking lopped teak trees in Travancore. The tree is found on considerable areas both in the low country and on the hills up to 3,000 feet elevation. The teak over this area is largely lopped for fodder, and in the rotten wood which forms by decay at these wounds, the moth lays her eggs about April. The larva is smooth, without hairs, and red in colour; it probably spends over a year boring inside the wood. The tunnel formed is a winding one. The pupa is apparently not enclosed in a cocoon. It is spiny, the spines being made use of to enable it to work up the tunnel to the opening to the outside, thus enabling the moth to creep out of the hole originally bored to the outside by the larva for this purpose.* When trees are badly attacked they are said to die down, only the base of the stem remaining, which throws out suckers.

The well-known coffee-borer of Southern India, *Zeuzera coffeæ*, belongs to this family, the larva feeding in the coffee branches and stems, and, it is said, in the roots, and killing them off. It is also said to attack the stems and roots of the sandal wood, young saplings of this tree being either killed outright or so weakened that they are thrown down by the first storm.† Fig. 260 shows the larva in a stem, pupa, empty pupal case projecting from wood and moth of this pest.

The writer has had an opportunity of examining both coffee and sandal wood in the Madras Presidency, both young saplings and older trees, and his investigations, although they have not been carried far enough at present, lead him to suspect that the real pest of these trees and the one which causes the most serious injury is a longicorn grub (*Cerambycidæ*) which attacks the trees in their sapling stage, and, usually starting in a branch, works its way down to the heart of the stem, perhaps hibernating in the cold weather in the roots. Whilst the coffee boring caterpillar undoubtedly does damage to both coffee and sandal-wood, investigations will not unlikely show that this damage is by no means so severe as that done by its beetle grub companion. Since on the one hand coffee bushes are killed off, or are so riddled by the grubs, as to be useless, whilst on the other the tunnels in the heart of the sandal sapling although not killing the plant reduce the value of the wood for sale purposes when the tree is finally cut over, it becomes obvious that it is imperative that the habits of these borers should be thoroughly understood.

* *Vide* Injurious Insects of Indian Forests, p. 102, Fig. 67.

† *Vide* Injurious Insects of Indian Forests, p. 104, Fig. 68.



259 *Duomitus leuconotus* *a*, dorsal and side view of larva ; *b*, pupa ; *c*, empty pupal case projecting from a tunnel *d*, moth , e. portion of stem of a *Cassia nodoso* tree showing tunnels of larvæ and empty pupal cases

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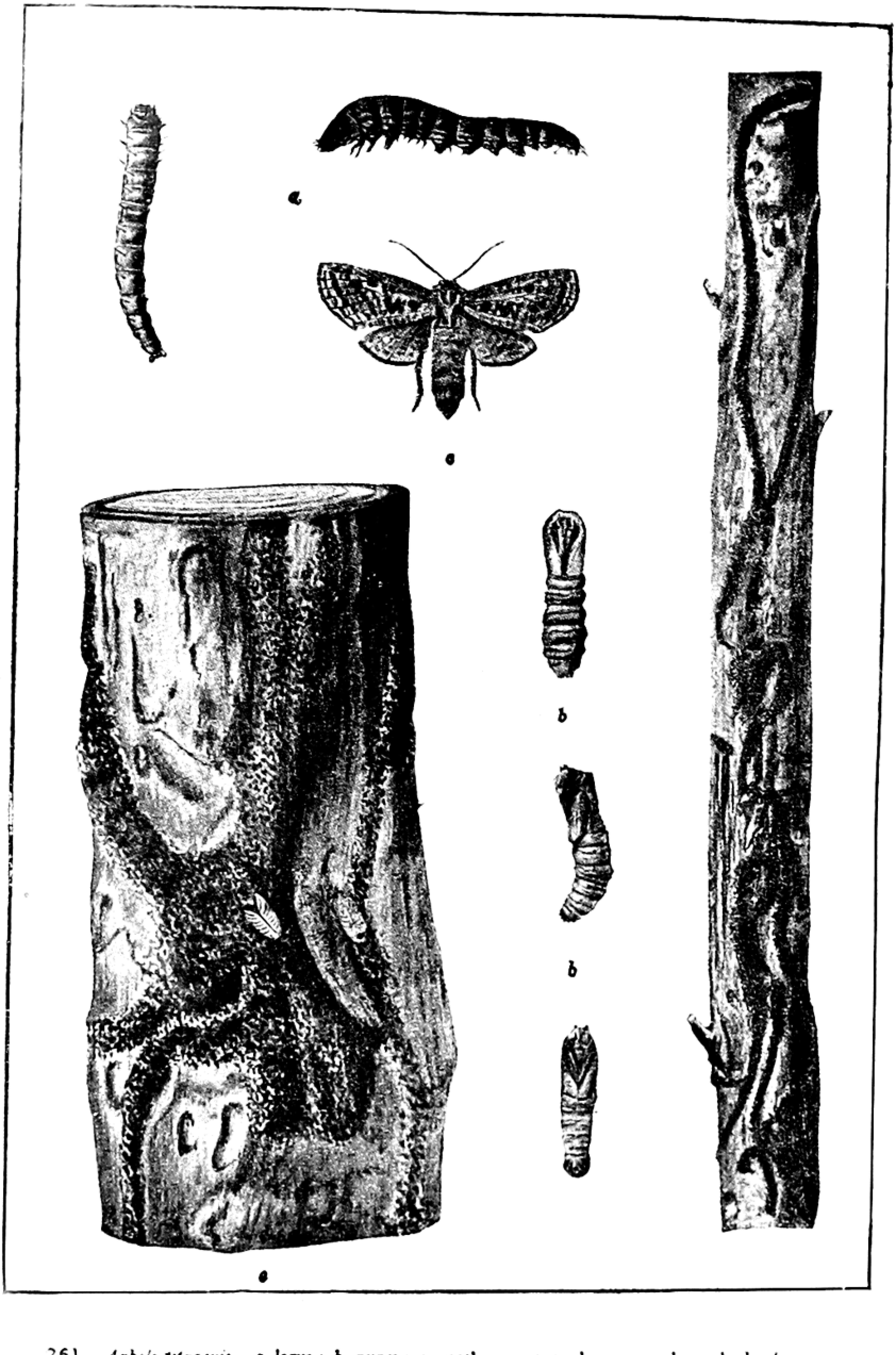

261. *Arbela tetraonis.* *a*, larva ; *b*, pupæ ; *c*, moth ; *d*, covered ways made on bark of stem by the caterpillars (reduced) ; *e*, covered ways on a section of a stem ($\frac{2}{3}$rds nat. size).

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FAMILY IX.—*Arbelidæ.*

Allied to the *Cossidæ*. Proboscis and frenulum absent. Antennæ bi-pectinated to tips, the branches being short. Wing nervures less complex. The family is thought to have very similar habits to those of the *Cossidæ*, the larvæ being wood-borers. One at least, however, *Arbela tetraonis*, feeds upon bark, only boring into the wood of the tree to pupate.

Life-history of *Arbela tetraonis*.

The caterpillar of this insect feeds upon the bark of the Casuarina tree. It is abundant in plantations growing on the east coast of Madras, both young and old trees being attacked. The larva lives in a 'covered way' made on the bark consisting of silk and droppings (see fig. 261). It is a flesh-coloured caterpillar with a black head and pinkish swollen thoracic segments which bear three pairs of stout legs; the segments have scattered hairs. Pupa yellowish brown, furnished with circular rows of spines; moth greyish with dull brown spots, forming bands in places. The moth appears in June and July and lays eggs on the bark. These hatch soon after being laid, and the larvæ feed solitary upon the young outer bark. The covered ways are commenced almost at once. When full fed the larva bores into the wood and pupates. When the moth is ready to issue the pupa wriggles to the mouth of the hole. The attacks can be easily recognised owing to the presence of the conspicuous covered ways upon the bark. Fig. 261, *a*—*e*, shows the various stages in the metamorphosis of this insect and the covered ways on the outside of a stem. Serious attacks of this insect were experienced in plantations in Ganjam in 1903-04. The insect swarmed in such numbers that it became necessary to modify the provisions of the working-plan and to cut out a large number of trees.

FAMILY X.—*Hepialidæ* (Ghost and Swift Moths).

Moths of varying size, some being gigantic. The wings do not fit well together at their bases; no proboscis is present, and no frenulum; the scales on the wings are imperfect. The larvæ are nearly bare of hairs, and they live either in the earth, feeding upon the roots of plants, or they burrow in the wood of trees and shrubs. The chrysalis is generally elongate and cylindrical in form and very agile, having a considerable number of spines on its dorsal aspect; by the aid of these the pupa is able, by wriggling, to move a considerable distance in the tunnel in the wood.

The eggs in this family as well as in the families *Ægeriidæ* and *Cossidæ* above alluded to are usually laid upon the bark. The caterpillar tunnels into the wood. The tunnels so made are kept open by the larva, and it occasionally comes out and feeds upon the

bark. It often builds for itself a covered gallery of silk and excrement, this gallery being very conspicuous on tree trunks. When a larva feeds in this way the tree attacked will be often found to have a juicy, soft succulent bark.

The larvæ of the genus Phassus bore in the trunks of trees. Fig. 262 shows the moth *Phassus signifer* of Burma.

Very little is at present known about the operations of these moths in Indian forests, but grubs thought to be Hepialid have been reported as boring into teak wood at the Nilumbur plantations and into young teak saplings in plantations in the Prome division. These reports require careful observation and confirmation.

FAMILY XI.—*Lasiocampidæ* (Eggers, Lappet Moths).

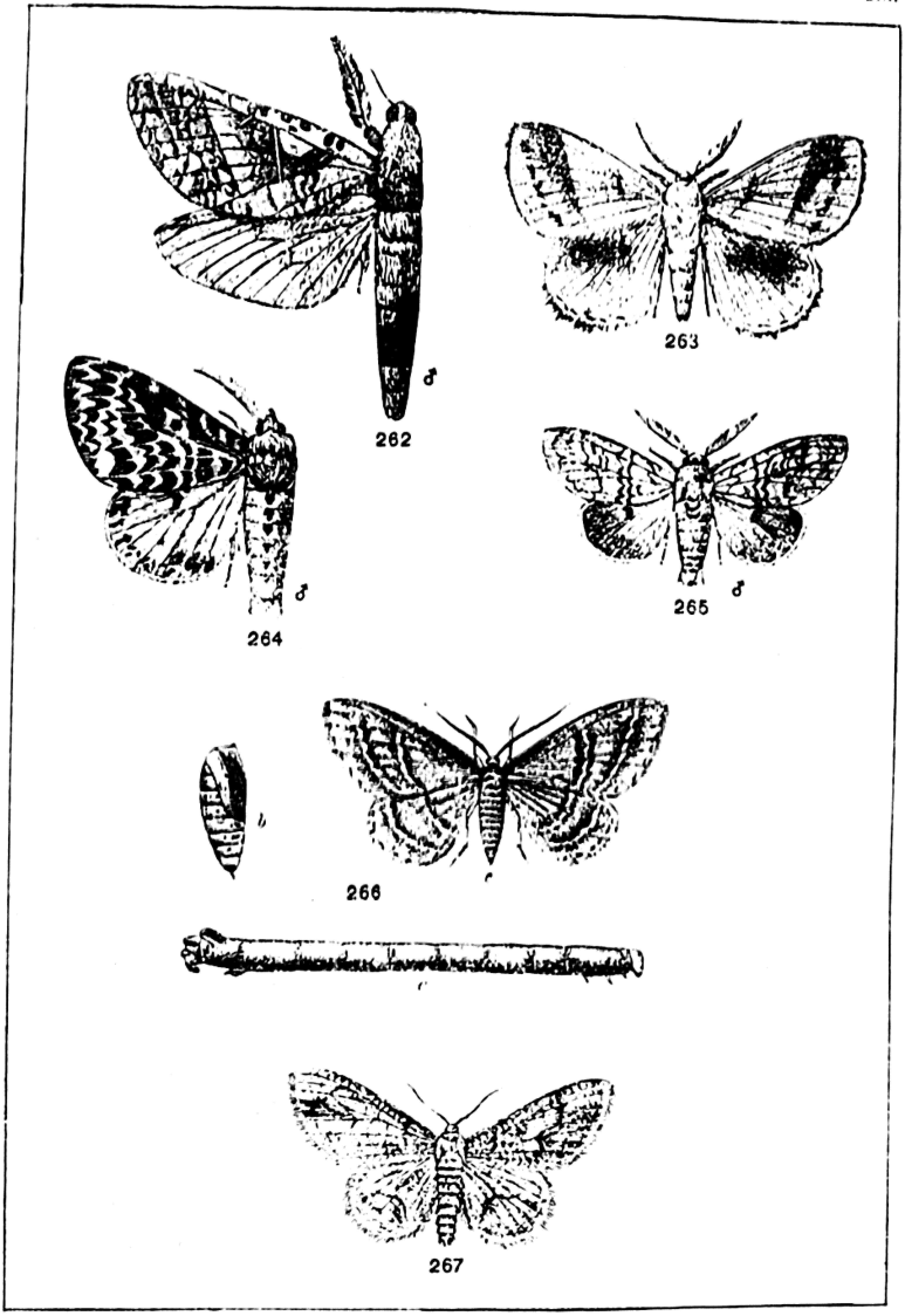
These moths are usually large, are densely covered with scales, and have no frenulum. The costal area of the hind wing is largely developed. The antennæ in the male are highly pectinate. These characters render it easy to distinguish a Lasiocampid moth. There is at times a great difference in size between the ♂ and ♀, the latter having three times as great an expanse of wing as the ♂. The eggs are smooth and sometimes spotted in an irregular manner like bird's eggs. They are often covered with hair by the female. The larvæ are clothed with a soft woolly hair as well as with short stiffer hairs. These hairs are not arranged in definite tufts and pencils, nor are they as highly coloured as in the case of the larvæ of the next family to be considered, the Lymantriidæ, and thus they can be distinguished from these latter. The hair has sometimes very irritating properties. The caterpillar spins a cocoon in which the hairs of the body are often mixed. In some species the walls of the cocoon have a firm appearance, looking very like egg-shells, and this has probably given rise to the name of 'eggers.' The caterpillars feed on leaves and probably do some damage in this way.

An example of one of these Lasiocampid defoliators is an insect, by name *Suana concolor*, whose larvæ feed upon the leaves of the sâl tree in the Siwaîlk forests in the United Provinces.

The caterpillars of this insect are large, over 3 inches in length when full grown in October, and grey in colour, with irregularly arranged tufts of soft hair.

Life-history of *Suana concolor*.

They pupate in November, spinning a strong hairy silken cocoon on to the bark or a branch of the tree. The winter is spent in the pupal stage, the moth appearing about the end of March. The rest of the life-history has yet to be worked out, but the



262. *Phassus signifer.*
263. *Trabala Vishnu.*
264. *Lymantria mathura.*
265. *Dasychira horsfieldi.*
266. Larva, pupa and moth of *Boarmia selenaria.*
267. *Biston suppressaria.*

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female probably lays its eggs on or near the sál twigs, and the young caterpillars hatching out feed upon the new flush of leaves which appears in April. The moth is grey in colour and answers the above description of a Lasiocampid moth.*

Fig. 242 shows the larva, cocoon, pupa, and moth of this insect. A Small Lasiocampid moth whose caterpillar defoliates (see below) sál trees in Assam is *Trabala Vishnu* shown in fig. 263.

FAMILY XII.—*Lymantriidæ or Liparidæ.*

Mostly small or moderately sized moths, without brilliant colouring; whites, greys, browns, and blacks being the predominant tints in the family; the male has the antennæ highly pectinated. The larva is very hairy and usually bears tufts or brushes of shorter hairs, together with others much longer and softer; these being sometimes amalgamated to form pencils, the tufts and pencils having a definite arrangement on the insect. The colouration of the larvæ is often very conspicuous, the tufts and pencils of hair being of vivid and contrasted colours. This arrangement and colouration of the hairs distinguishes these larvæ from Lasiocampid caterpillars. Anyone going into a tropical or semi-tropical forest at the commencement of the monsoon will easily note the great variety and brilliant colouration of the caterpillars of this family.

The larvæ form a cocoon in which much hair is mixed up. The pupæ are very remarkable, as they are sometimes also hairy, which is very unusual in the Lepidoptera.

This is an important family of moths, as it contains species which occasionally increase in enormous numbers and commit great ravages. One of the first allusions to such an event having taken place in an Indian forest is contained in a description, by Mr. W. E. Fisher, † late Conservator of Forests, of a severe attack by caterpillars of this family in the sál forests of Assam. This occurred in 1878, the trees being completely stripped of all their leaves.

Life-history of *Dasychira horsfieldi* and *Lymantria* spp.

The eggs are laid by the female moths on the young leaves of the tree. The caterpillars on hatching out at once commence to defoliate the trees, and in the attack in question an area of over 200 square miles of sál forests was completely stripped of all leaves, the trees being rendered perfectly bare and the ground being strewn with their débris and with the caterpillars' droppings. In 1897 Mr. Campbell ‡ reported an attack to have spread over 800 square miles in Assam, all the trees associated with the sál, such as *Bombax malabaricum*,

* *Vide* Departmental Notes Vol. I. p. 58.

† *Vide* Indian Forester, Vol. VI, p. 243 (1881).

‡ *Ibid*, Vol. XXIV, p. 9 (1898).

Careya arborea, and *Dillenia pentagyna*, etc., being also defoliated; at the same time he noted that pure sál forest had suffered more than mixed. In this attack the larvæ first appeared in August, a second generation appearing in November, a third about the end of January, and a fourth towards the end of March. The chief insect responsible was a species of *Dasychira*, probably *D. horsfieldi* (fig. 265). This insect was accompanied by *Leucoma diaphana* in August, by *Trabala Vishnu* (fig. 263) (Lasiocampid) in May, and by *Lymantria grandis* in all the attacks.* In 1899 all the sál trees in the Duars in Bengal were defoliated in a similar manner, four different species of *Lymantria* moths, sent to the writer by Sir H. A. Farrington, the Officer in charge of the forests, being concerned in the attack.† It is not certain how many species or the caterpillars of which moth were responsible for the Assam defoliation, as confusion appears to have arisen in the identifications of the insects sent. Fig. 264 shows the moth *Lymantria mathura*. *L. lepcha* and *L. bivittata* also defoliate the Sál in Goalpara and the Bengal Duars.

The larvæ of the moth *Gazalina apsara* have been reported as defoliating *Quercus lamellosa* in the North East Himalayas (Darjiling forests).

From what has been written it will thus be seen that species of this family when they swarm in large numbers are a source of serious danger to the forest.

FAMILY XIII.—*Geometridæ* (Geometers).

An extensive family of fragile moths having a large wing area, the antennæ being frequently highly developed in the males. The larvæ are elongate and slender having, in addition to the three pairs of thoracic legs, only one pair of abdominal pro-legs placed on the ninth segment and an anal pair. They progress by moving these two pairs of feet up to the thoracic legs, so that the body is thrown into a large hoop, and then moving forward the thoracic legs; owing to this habit of progression they are called loopers or Geometers. The number of these larval legs and the resultant mode of walking is one of the most constant characters of the group. The larvæ assume various attitudes in repose, either clinging on to the stem with their pro-legs, holding the rest of their body straight out at an angle from the twig, being attached to it anteriorly, however, by a strand of silk projecting from the mouth; or they prop themselves up between two twigs more or less at right angles to each other. They often vary in colour, the same species being either green or brown, and this colouration and the markings upon them often gives them a great resemblance to their food plant; they appear, however,

* *Vide* Departmental Notes Insects which affect Forestry, Vol. 1, p. 63.

† *Ibid*, pp. 66-77.

to make little or no use of this character for protective purposes, as they might be expected to do.

The larvæ are defoliators, but little is known about their operations in Indian forests at present.

Life-history of Boarmia selenaria.

The following is a portion of the life-history of a typical member of the family by name *Boarmia selenaria* :—

The full-grown caterpillar is a looper of the ordinary type, bright green or brown in colour and about 2 inches in length. The moth is greyish,

In the sál forests of the Siwaliks (on the Dun side of the range) a plague of these caterpillars appeared about the middle of April 1901, and in parts entirely stripped the trees of all the new year's-shoots, leaves, and flowers. Young saplings suffered very severely, and it was noted that towards the end of September they had no green shoots upon them, many bearing numerous dead branches. The growth of the year in the portions of the forest most heavily attacked was *nil*. Sál of all ages were attacked. The pupal stage was a short one, and moths were bred out in May. The insect has since been reported from Garhwal where two generations of caterpillars were noted in 1906. Fig. 266 shows the caterpillar, pupa, and moth.

Another pest of this family is *Biston suppressaria*, a greyish moth with black markings. The caterpillar is green and has been reported as seriously defoliating the brushwood forests of the Lower Murree Hills (3,000–4,000 feet). It was noticed in July when nearly full grown. It pupated in August, and three weeks after the moths appeared (in September). Fig. 267 shows the larva, pupa, and moth of this pest. The species it more or less completely defoliates are *Dodonea viscosa, Carissa diffusa, Bauhinia variegata, Acacia catechu, Acacia modesta, Rothra tinctoria*, and *Cassia auriculata*.

FAMILY XIV.—*Noctuidæ*.

A very large family of moths, generally of sombre colours, the insects being with some exceptions very rarely seen in the day time. Both proboscis and frenulum are present and the antennæ are not highly pectinated in the male. About 8,000 species are known, and owing to their great general resemblance their classification is difficult. The larvæ are, as a rule, destitute of large tufts of hair and are not brilliantly coloured ; they are fond of concealing themselves during the day and coming out to feed at night, and thus when defoliating trees they are very apt to be overlooked, as when searched for during the daytime they are not to be found upon the leaves and twigs. Many of the caterpillars of the family pass most of their time at or

beneath the surface of the ground finding nourishment in roots or the lower part of the stems of plants. This is especially the case in the genus *Agrotis*, perhaps the most widely distributed of all the genera of moths. In some forms the abdominal clasper legs are reduced to two in number, and we then get larvæ resembling the loopers of the last family the caterpillars being then known as "semi-loopers." (cf. fig. 273).

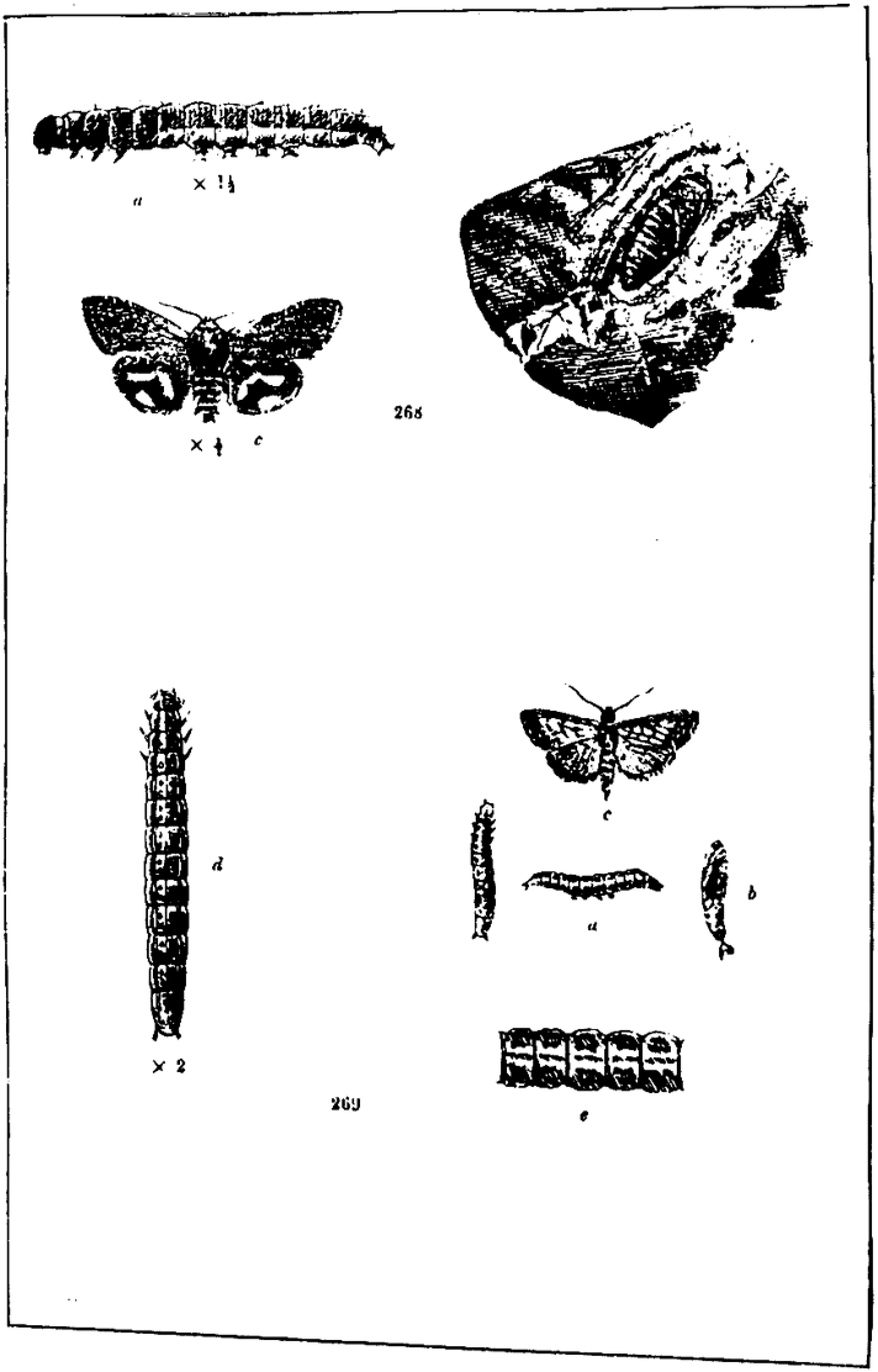
Noctuid larvæ either defoliate trees and plants, or they may have a limited wood-boring capacity. Others feed in the seeds of plants or live upon the roots, either feeding upon the smaller ones or tunnelling into the larger ones. The larvæ living upon leaves are usually hairy to a certain extent and spin a cocoon before changing into the pupal state; those living in the wood form a rough cocoon of hairs and chips of wood, whilst those pupating in the ground usually build an earthen cell to change in. In Indian forests we have representatives typical of each of these methods of feeding and pupating.

Life-history of *Hyblæa puera*.

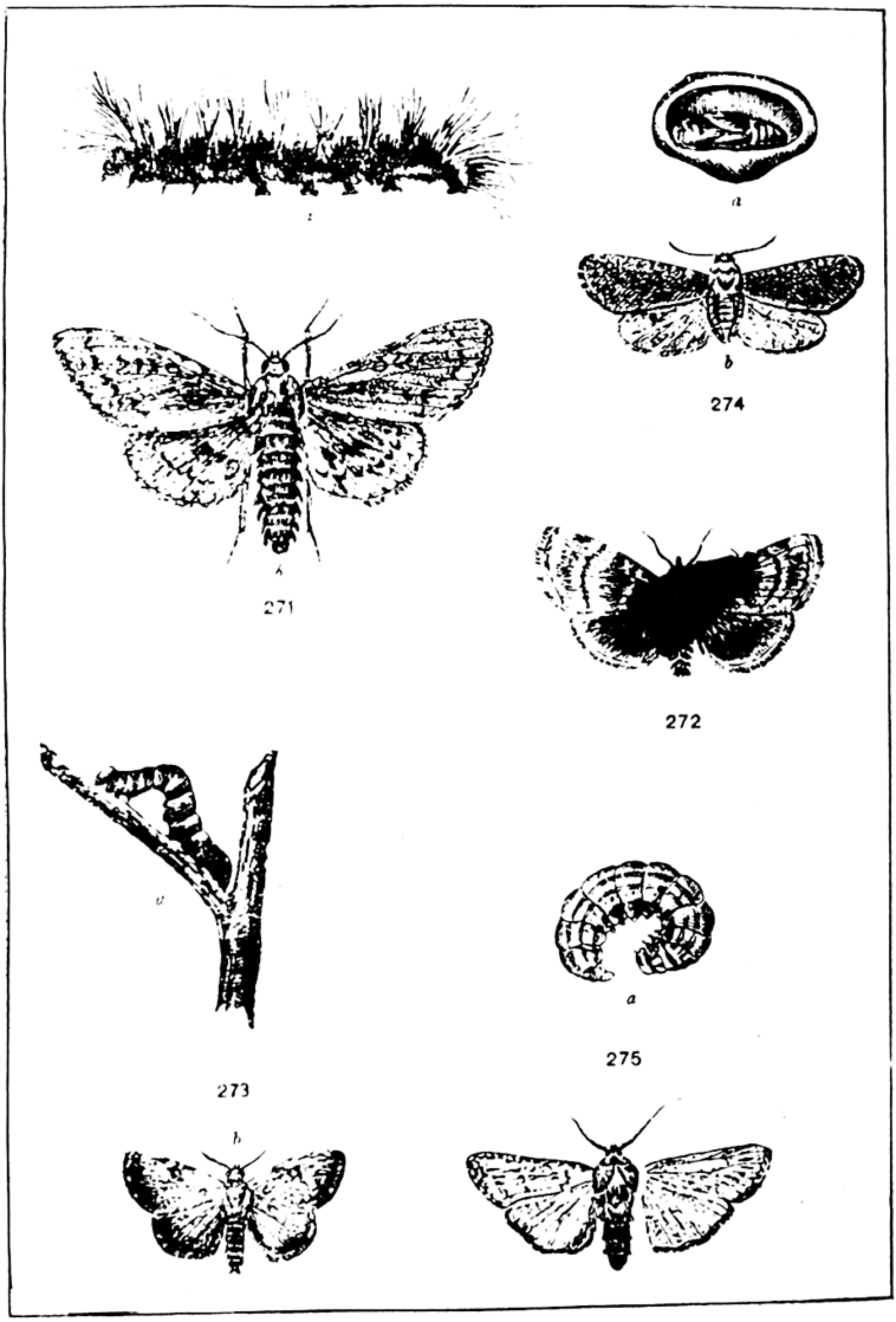
Hyblæa puera is the well-known teak leaf defoliator of the teak areas of India and Siam. The eggs are laid upon the leaves or twigs of the tree, and the larvæ commence their defoliating operations some time in April (the period of course varies in different parts of India, being later in the drier tracts), and the insect passes through several generations—the number being at times as many as seven—in the year. The defoliation is easily recognisable as the caterpillar, in feeding upon the leaf, leaves intact the main rib and the side veins, eating all the green leaf tissue between these. The larvæ pupate either in rolled-up portions of the leaf itself or on dead leaves upon the ground. The moth is small and dusky in colour, with reddish patches on the hind wings. It is apparently to be found all over India wherever the teak exists, and the larvæ at times entirely strip the teak of their leaves at least twice in the same year.* Fig. 268 shows the larva, pupa, moth, and fig. 270*a* a defoliated teak leaf. The insect is usually accompanied by the larvæ of the moth *Pyrausta machœralis* (fig. 269) described under *Pyralidæ*. In Burma and Siam it is also accompanied by *Hyblæa constellata*.

Acronycta anædina (fig. 271) defoliates the horse chestnut in the North-West Himalayas. The larva is a hairy caterpillar, blueblack in colour, with tufts of bright yellow hair. The moth has a greyish appearance and lays her eggs in July. The caterpillars feed upon the leaves in August and spin a rough hairy cocoon at the end of the month. The winter is passed in the pupal stage, the moths hatching out at the beginning of the following July. The caterpillars at times

* *Vide* Departmental Notes on Insects that affect Forestry, Vol. I, p. 287, for a fuller description; also Plate XVIII, Fig. 1, Plate XIX, Fig. 1, *a*, *b*, *c*, *d*; *Injurious Insects*, Fig. 78



268. *Hyblaea puera.* *a*, larva ; *b*, pupa in a rolled up portion of teak leaf ; *c*, moth
269. *Paliga damastesalis.* *a*, *b*, *c*, larva, pupa and moth, natural size ; *d*, larva enlarged ; *e*, part of larvae skin, enlarged.



271. *Acronycta anardina.* *a*, larva ; *b*, moth.

272. *Cosmia ochreimargo.*

273. *Plecoptera reflexa.* *a*, larva ; *b*, moth.

274. *Mudaria cornifrons.* *a*, pupa in mud cell ; *b*, moth.

275. *Agrotis ypsilon.* *a*, larva ; *b*, moth.

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completely defoliate the trees. They are badly parasitised by the ichneumon *Ophion aureolatus* (*vide* p. 61).

Cosmia othreimargo defoliates the oak *Quercus semicarpifolia* in the North-West Himalayas, the larvæ being full fed about the middle of July and the moth issuing in August. (See fig. 272.)

The caterpillars of *Plecoptera reflexa* defoliate young Sissu growth in the Changa Manga Plantation. They are semi-loopers. They appear in April and spend several weeks feeding upon the trees. When full grown they descend and pupate in the ground towards the end of June. The moths appear in July. Fig. 273 shows the larva and moth.

Life-history of the silk-cotton pod moth *Mudaria cornifrons*.

The silk-cotton pod caterpillar, *Mudaria cornifrons*, destroys the pods of the silk-cotton tree (*Bombax malabaricum*). The eggs are laid in the flower or immature pods of the trees in February-March according to when the tree flowers; the larva on hatching out tunnels into the pod and remains feeding in it until the latter falls to the ground. When full fed, the caterpillar bores its way out and burrows into the ground and constructs the earthen cell typical of the hairless Nocuid larvæ (fig. 274*a*). The grub then changes into the pupal state and passes the rest of the year—hot weather, rains, and cold weather,—until the succeeding February, in this cell. The moth (fig. 274*b*) on coming out lays her eggs in the flower or immature fruits of next year's crop.*

Life-history of *Agrotis ypsilon*.

The genus *Agrotis* includes the typical subterranean noctuid larvæ who spend the whole of their larval life in the earth feeding upon roots, etc. A widely spread Indian species is *Agrotis ypsilon*; the caterpillars, which are known as "cut worms," often committing great havoc amongst crops. Up to recently it had not been reported as dangerous in the forest, but in 1900 Mr. B. O. Coventry found it eating young deodar seedlings in the Gora Gali Nursery near Rawalpindi, and the author discovered it committing the same damage in nurseries in the Simla Hills the following year. This larva feeds upon the roots and also comes above ground at nights and in dull cloudy weather, and cuts off young seedlings close to the soil surface, and either leaves them to die *in situ* or drags some to its hole to feed upon, thus acting much in the same way as the cricket *Brachytrupes achatinus* and the cockchafer grub already described. Fig. 275 shows the larva and moth of this pest. We at present know very little about the wood-boring Noctuids in India.

The caterpillars of *Eublemma amabilis* parasitise the lac insect feeding upon the lac young.

FAMILY XV.—*Pyralidæ*.

This division must be considered rather as a group of families than as a single one. It includes a very large number of small or moderate-sized moths of fragile structure and frequently long legs; the antennæ are simple, being only in a few cases pectinate. The larvæ

* *Ibid*, p. 113, Plate VIII, and Departmental otes, Vol. I, p. 81.

are usually nearly bare, with only short scattered hairs and little colouration; they have most varied habits, are fond of concealment, and are very lively and abrupt in their movements, wriggling backwards and forwards when disturbed. They form a cocoon before changing to the pupal state. Both the leaves and the seed of trees are known to suffer from the depredations of these caterpillars in India.

Life-history of Pyrausta machæralis.

One of the widest known defoliators of the family in India is *Pyrausta machæralis*, which in its larval stage strips the teak of its leaves all over the country, working often in company with *Hyblæa puera*. This insect has as many as seven generations in the year. It spends the winter as a larva in the ground, in the Central Provinces, appearing as a moth in May and laying the eggs of the first-generation of the year upon the leaves of the tree. As these moths do not all appear exactly at the same time the egg-laying is spread over several days, and as the eggs first laid hatch out first we have a series of uninterrupted and overlapping generations provided up to November or even December, and one or more of them may produce an enormous number of individuals, the caterpillars stripping the entire crop of leaves from the trees. In feeding the larvæ do not touch any of the veins of the leaf, but only eat the parenchyma thus "skeletonising" it. Fig. 269 shows the larva and moth, and fig. 270*b* a skeletonised leaf. Mr. R. S. Hole gives the following as the period approximately spent in passing through a generation :—

From appearance of moth to hatching out of young larvæ laid by it	7 days
Larval stage	16 „
Pupal stage	7 „

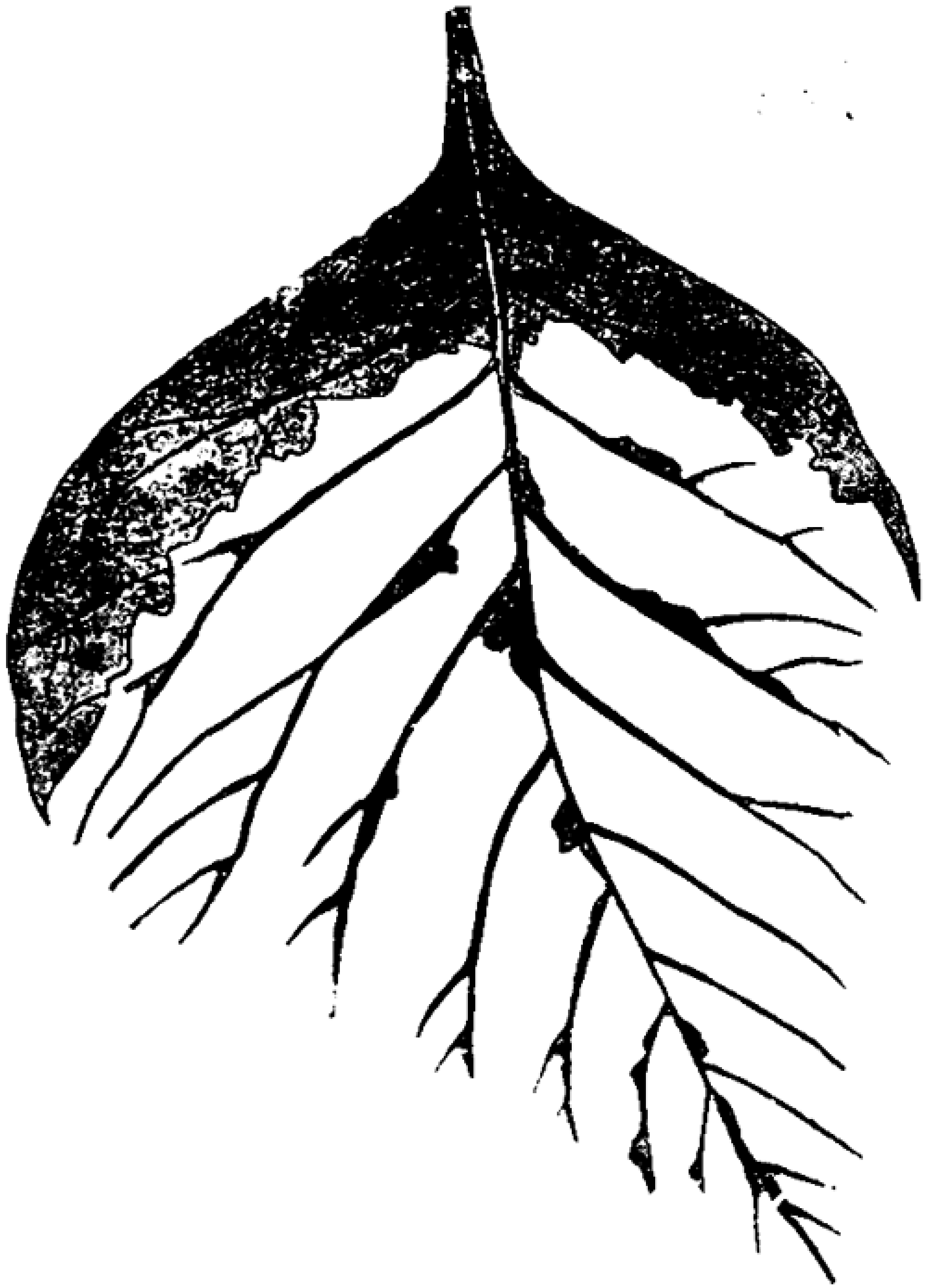
or 30 days for a complete generation.*

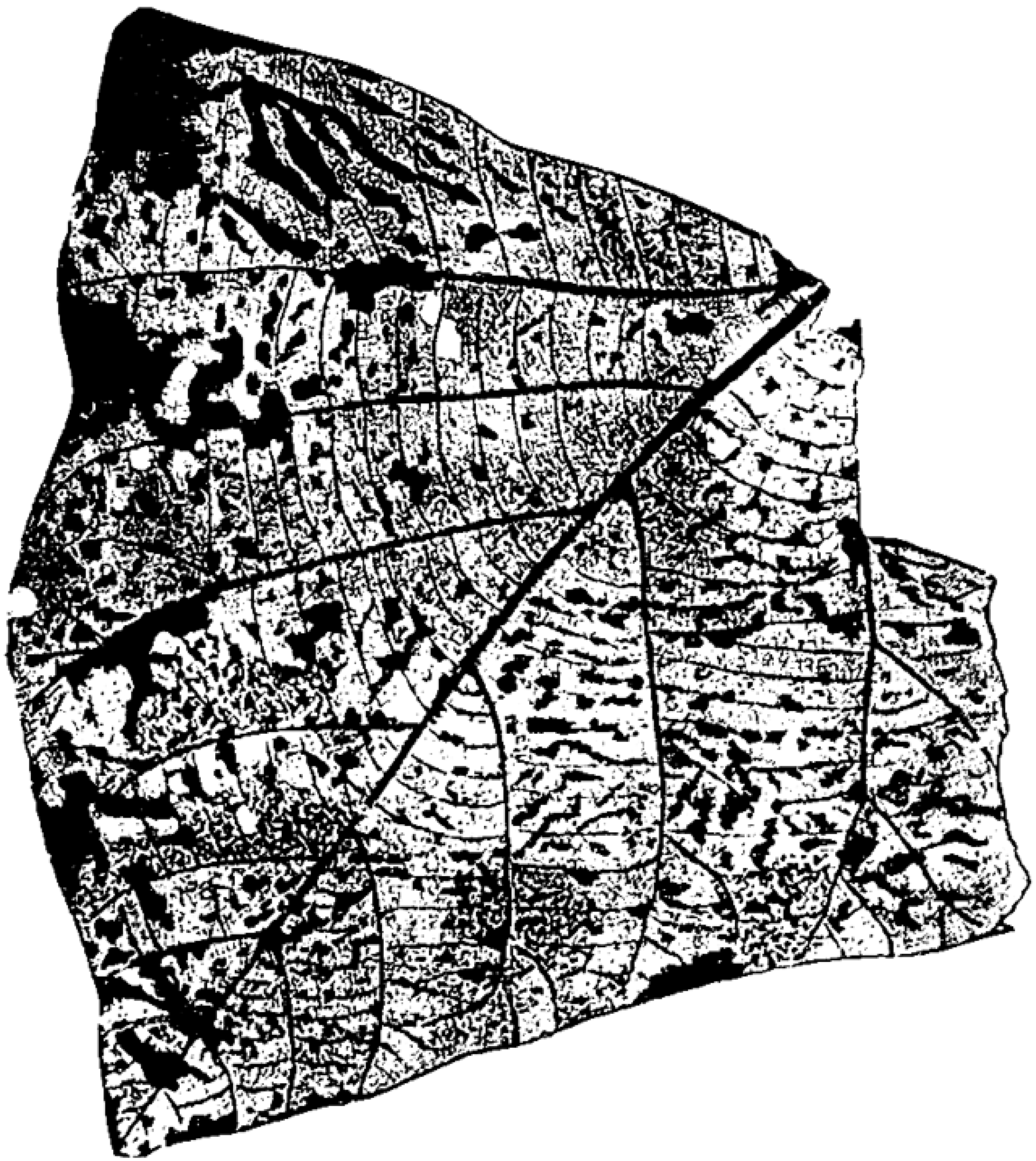
Life history of Hypsipyla robusta.

The caterpillars of the moth *Hypsipyla robusta* are the well-known Tun tree twig-borers. The larvæ are reddish when young, becoming bluish when full grown. The pupa is enclosed in a dense matted silk cocoon, the cocoons often being collected into a felted mass together beneath the bark, where the caterpillar pupates. The insect passes through two generations in the year in the plains of the Punjab. The larvæ first appear in April and feed upon the flowers and in the young fruits of the tree, being full fed in the middle of May. They only rarely attack the shoots at this period, though they are to be found in them. The larvæ feeding on the flowers and fruits pupate beneath the bark, those in the twigs inside them. The caterpillars of the second generation appear in August and live entirely in the twigs of the tree, hollowing them out and thus causing them to dry up and fall off.

Fig. 276,*a*—*d* shows larva, pupa, moth, and a mass of cocoons under the bark and a cocoon *in situ* in a hollowed-out branch.

* For a fuller description see Departmental Notes, Vol. I, p. 301, Plate XVIII, Fig. 2, Plate XIX, Fig. 2 (Larva).





270a. Teak leaf showing characteristic method of defoliation by the larvæ of Hyblæa puera. Cram.

270b. Portion of a Teak leaf showing the skeletonizing method of the larvæ of Pyrausta machœralis, Wlk.

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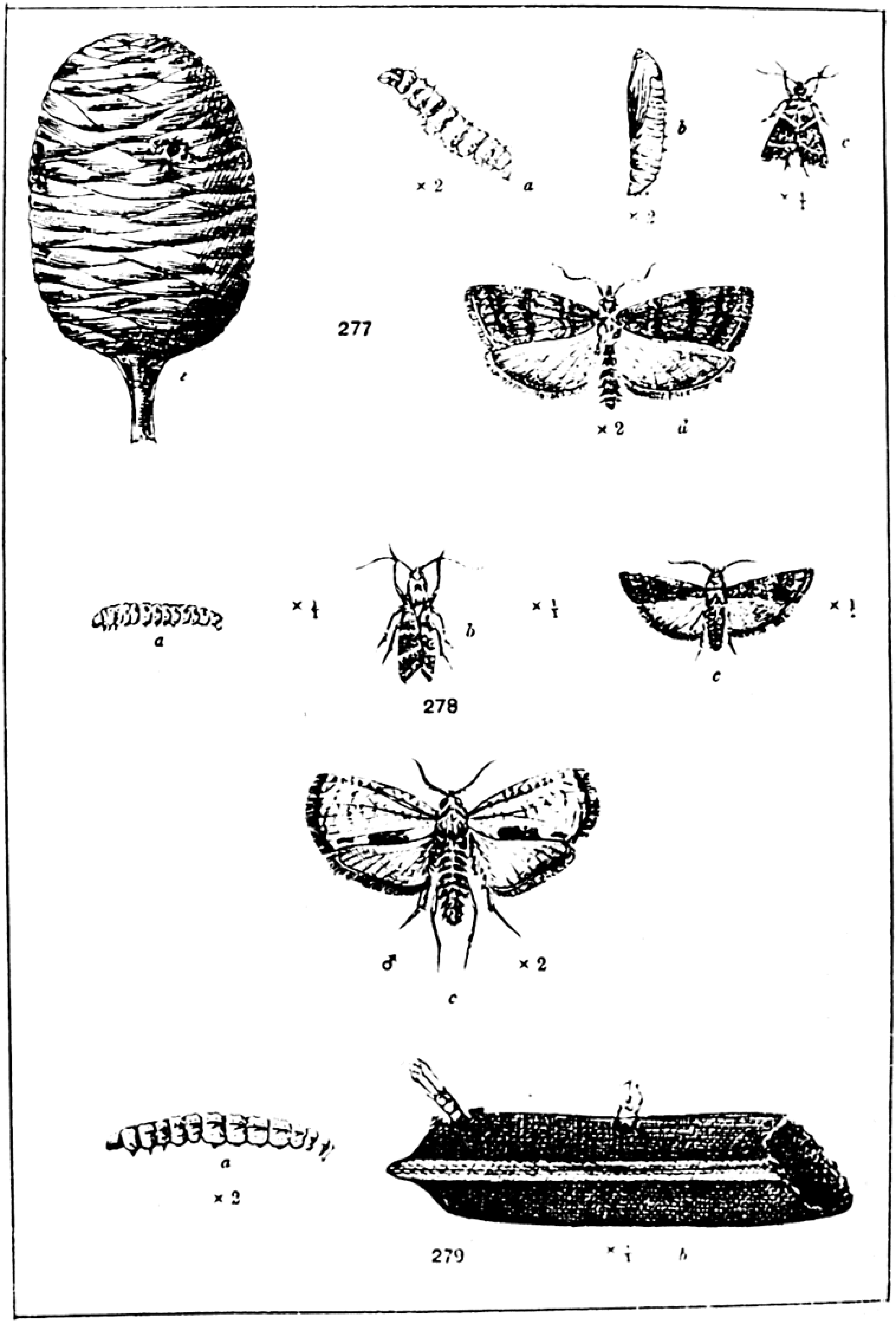

277. *Euzophora cedrella.* *a*, larva ; *b*, pupa ; *c*, *d*, moth, natural size and enlarged ; *e*. deodar cone showing attacks of larvæ.

278. *Phycita abietella.* *a*, larva ; *b*, *c*, moth.

279. *Cryptophlebia carpophaga.* *a*, larva ; *b*, pod with empty pupal cases projecting ; *c*, moth.

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Two other species of Pyralid, *Macalla moncusalis* and *Teridia calctoralis* have been reported as defoliating sál trees in Ganjam, Madras.

The grass moths, small insects which fold their wings tightly round the body and have a head pointed in front, belong here.

Species of the family have proved exceedingly destructive to deodar and other cones such as those of the spruce, silver fir, and blue pine. Mr. Ribbentrop, at the time Inspector General of Forests, noticed that nearly the whole of the crop of deodar cones on trees round Simla was destroyed in 1898 by a larva which proved to be a Pyralid. Recent observations have shown the author that not only deodar cones, but those of the silver fir, spruce, and blue pine are infested by one or other or both of two species of the family named *Euzophera cedrella* and *Phycita abietella* which have apparently much the same life-histories.

Life-history of *Euzophera cedrella* and *Phycita abietella*.

The eggs are laid by the moths sometimes in autumn, either on the flower buds or near them. The exact period at which the larvæ hatch out has not been observed, but they are to be found burrowing in the cones towards the end of May and continue to do so until about the beginning of August when they become full fed. The cone by now has become rotten and falls to the ground, and the larvæ either pupates within it or quits it and burrows into the soil. The moths issue in September and October. Fig. 277 a shows the caterpillar of *E. cedrella*, b, the pupa, c, the moth (nat. size) d, moth (enlarged) and e, an attacked deodar cone; Fig. 278 a, the larva of *P. abietella*, b, the moth (nat. size); and c (enlarged).

FAMILY XVI.—*Tortricidæ*.

Moths of small size with a rather large wing area, the wing fringes being never as long as the wings are wide, the hind wings without any pattern in them. The larvæ inhabit their food plant, which may be rolled up or twisted leaves, or the interior of fruits and herbs, or galls, or even roots. The larvæ have all sixteen legs present. The name *Tortricidæ* refers to the habit the larvæ have of rolling up leaves, or twisting and distorting shoots and buds.

Little is known about this family in India. A species of *Tortrix* defoliates the oak, *Quercus semicarpifolia*, in Jaunsar in the North-West Himalayas, and a second, known as *Cryptophlebia carpophaga* accompanies T. *fructicasiella* in tunnelling into *Cassia Fistula* pods. Fig. 279 shows the larva, empty pupal case projecting from a pod and moth of *C. carpophaga*.

FAMILY XVII.—*Microlepidoptera*.

Small moths with the labial palpi more flexible and mobile than in other moths; usually separated and pointed. Hind wings frequently

with very long fringes, the wing being reduced in size and pointed at the top. The larvæ are very different in shape and nearly always conceal themselves. They feed upon a variety of substances such as clothes, furs, hair, horns, seeds, and probably defoliate to a certain extent. They also mine into leaves of trees. Little is known at present about the family, although it probably contains numerous forest pests. The spruce bud binder, *Eucosma* sp., is one of these small moths.

The moth lays its egg upon the terminal bud of the spruce branches, probably some time in the summer. The egg remains here until the following spring, and hatches out before the young opening needles of the bud have pushed off the outer cap or covering. The young larva on issuing at once spins the tips of the needles together, thus preventing their opening and parting and forming a shelter in which it lives feeding upon the inner and more succulent of the needles. Some weeks are spent in this stage, and the grub then changes to a pupa within the hollowed-out bud, and after about ten days passed in this stage the moth emerges, the external needles of the shelter having by then dried and parted. The author has seen trees with as many as 70 per cent. to 80 per cent. of the terminal buds treated in this way. Fig. 280 shows the larva, pupa, moth, and a terminal spruce bud.

. Life history of *Eucosmo* sp. The spruce bud-binder.

The larvæ of *Ypsolophus* sp. defoliates Sissu trees at Changa Manga. The caterpillars appear in April, becoming full grown at the end of the month. In their feeding operations they cover the trees with vast quantities of silk. The moth appears at the beginning of May. Fig. 281 shows the larva, pupa in a leaf, and moth.

Species of *Tinea* (fig. 282) defoliate the oak *Quercus semicarpifolia* in June and July in Jaunsar, North-West-Himalayas.

Useful Lepidoptera.

Although Lepidoptera are the most exclusively vegetarian of all the orders of insects, a certain number of their larvæ prey upon insects, which are themselves filled with vegetable juices (such as Coccidæ or scale insects, Aphidæ or plant lice, etc.), and a very small number, *e. g.*, Tinea, etc., eat animal matter.

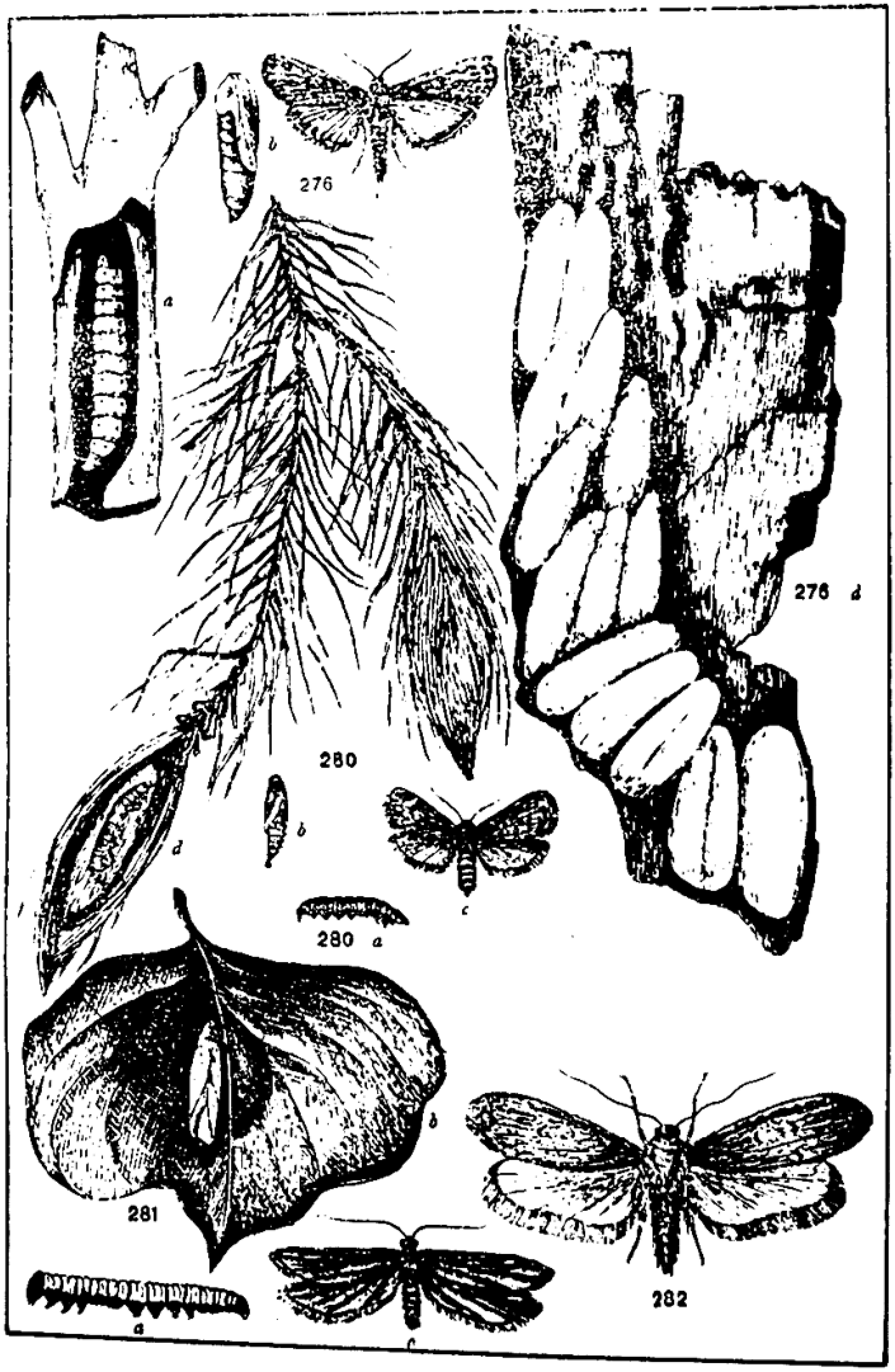
In the winged state Lepidoptera may be said to be useful as a whole, since many feed largely upon honey, which they collect from flowers, and in doing this they thus become important agents in the distribution of pollen from flower to flower, since it adheres to their scales and hairs whilst they are obtaining the honey from the flower.

The Heterocera or moths include several insects which may be considered to be of considerable use to man. Amongst them are the silkworm moths of the

family Bombycidæ. The mulberry silk-worm, *Bombyx mori*, is the cultivated variety of the plains of Bengal, whilst in the forest there are the important Tusser (*Antheræa mylitta*) silk-worm of Chota Nagpur and the Central Provinces, the Muga worm in parts of Southern India, the *Antheræa assama* of Assam, and the eri worm (*Antheræa ricini.*)

The Noctuidæ contain the genus *Erastria*, the larva of a species of which is predaceous upon a Lecanium scale insect which infests the peach in Southern Eur, pe. It may be found that the forester in India has allies of this nature in the family.

The genus *Eublemma* contains the noxious pest *E. amabilis* which preys upon and destroys the lac insect.



276. *Hypsipyla robusta.* The Toon tree borer; *a*, larva in branch of a Toon tree; *b*, pupa; *c*, moth; *d*, mass of cocoons enclosing pupæ beneath bark of tree.
280. *Eucosma sp.* *a*, larva; *b*, pupa; *c*, moth; *d*, Spruce branch with two terminal buds (one in section showing larva *in situ*) infested by larvæ.
281. *Ypsolophus sp.* *a*, larva; *b*, pupa attached to a sissu leaf; *c*, moth.
282. *Tinea sp.*

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CHAPTER IX.

ORDER VII.—DIPTERA (Flies).

The Diptera comprise the two-winged flies, including also the fleas which are wingless, and the parasitic wingless insects such as the sheep-ticks. The exceptions to the general two-winged rule in this order are very few, although there are probably some 50,000 species known and an enormous number still unknown.

The scavenger-like habits of some and the annoyance caused by others have rendered the insects unpopular and caused their study to be much neglected. Flies may perhaps be classed as actually the highest insects physiologically, for in them the processes of a complete life cycle are carried on with the greatest rapidity. A maggot hatching from the egg is able to grow with such rapidity that its full growth is completed in a few days; it then forms an impenetrable skin and dissolves itself almost completely; it then solidifies to a sort of jelly, and in a few days reconstructs itself as a being of totally different appearance and habits.

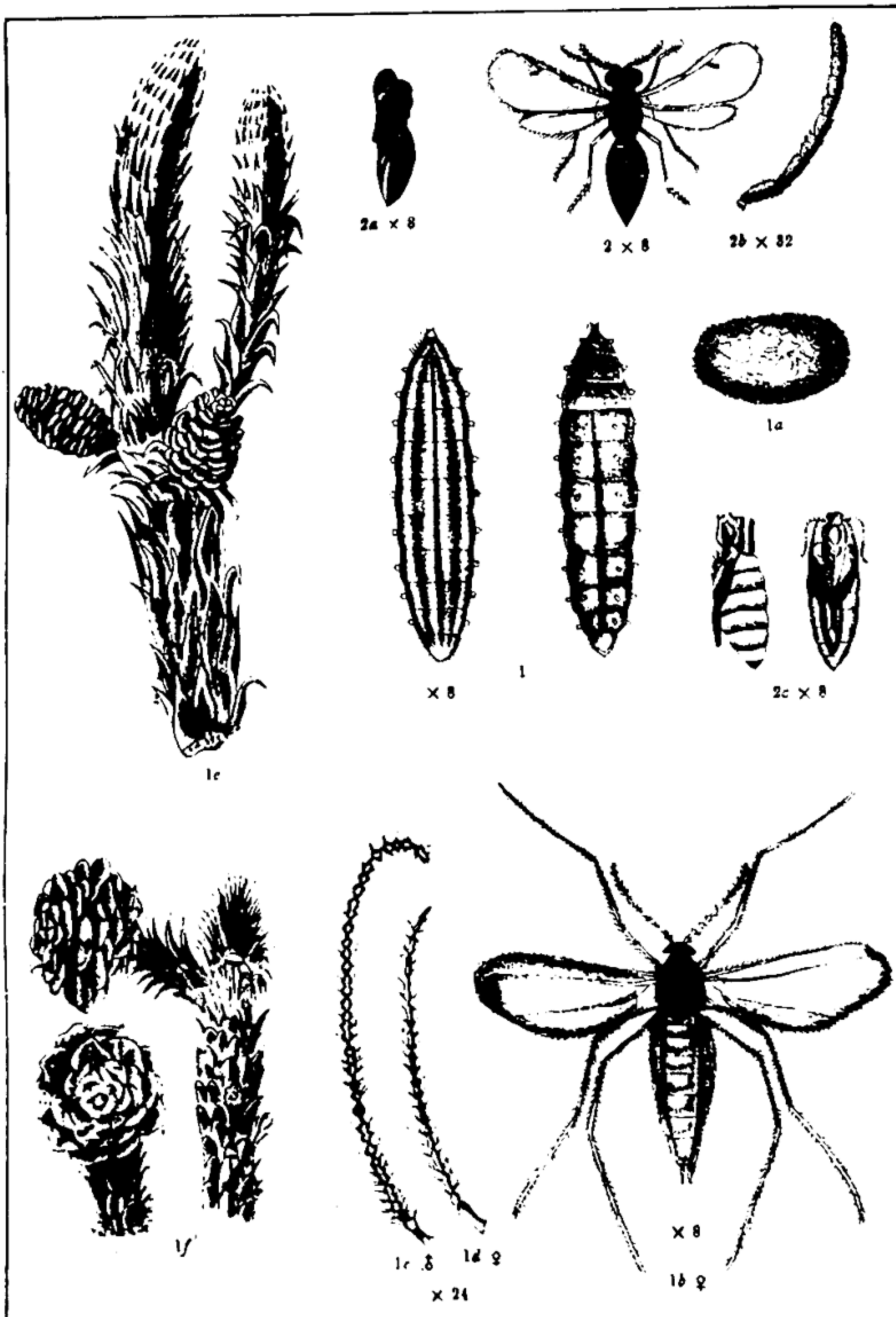
The wings of flies are usually transparent and never very large; they have a small piece attached to their lower inner angle, called the 'alula'; behind the wings there is situated a pair of small, erect capitate bodies, called the 'halteres' which are often concealed under membranous hoods and are used for balancing purposes. There is no distinct prothorax present, the thorax being an immovable mass; the head is very mobile and is connected with the thorax by a slender, concealed neck. A large part of the head is occupied by the big compound eyes, which are usually larger in the ♂ than in the ♀. The antennæ vary in structure and are of importance, the classification of the order being based upon them. In some a long-jointed antenna which may be whorled is present. The majority of flies have, however, an antenna peculiar to the order, consisting of three segments, the outer one of which is of diverse form and bears upon its front a fine projecting bristle, frequently feathered and often distinctly divided into two or more joints. This form of antenna is found in the

series Aschiza and Schizophora and is present in the common house-fly. In the order generally the two basal joints of the antennæ are called the 'scape'; the part beyond this is called the 'flagellum,' an appendage of the flagellum being termed the 'arista,' if bristle-like, or if thicker, 'the style' The mouth parts are formed for suction and consist of a sucking tube of varying form which sometimes ends in a flat pad as seen in the common house-fly. The legs are long and slender and terminate in claws with one or more pads between them which are covered with a sticky fluid which enables the insect to walk on glass surfaces, etc. The abdomen is conical and usually sessile. The larvæ are invariably maggots, *i.e*, they are legless. Some, however, still possess a hard chitinised head furnished with eyes, antennæ, and mouth parts. In others the head is not well marked, eyes are absent, antennæ absent, and mouth parts represented by a pair of darkly coloured chitinous hooks. Owing to the presence of such weak mouth parts the grub feeds upon decaying filth and refuse and other soft matters.

In those Diptera whose larvæ have well-developed heads, the pupæ are like those of the Lepidoptera, the appendages lying close to the body; in those with 'headless' grubs the pupæ remain within the last hardened larval skin and the pupa is then called 'coarctate.' In these latter no appendages whatsoever are to be seen on the outside, the chrysalis being generally blunt-ovate in form.

The Diptera are divided, according to the nature of the antennæ present, into five great series, a few families of each of which will be considered below. Although members of the order have not as yet been reported as committing much damage in Indian forests, it is not unlikely that we shall find as our knowledge increases that the gall-making ones are of considerable importance.

It may be mentioned here that the teak trees in the Melghat forest in Berar are badly attacked by a dipterous gall-making fly, uncertainly identified at present as probably a species of *Cecidomyia*. Under its attack the branches swell up into rounded lumps, which sometimes, completely encircle them, and these are at times so numerous as to distort the branch with irregularly-shaped swellings for some inches up, the galls often coalescing (cf. fig. 283). It would appear that when the gall completely encircles a branch or leading shoot of a young sapling the portion above it dies. The author bred out two of these flies from galls at the end of July in the Melghat, but unfortunately they got injured in transit to the British Museum and their identification was impossible. Teak in Madras



THE LONG-LEAFED PINE GALL-FLY AND ITS PARASITE.

284 The long-leafed pine Gall-fly and its Parasite (*Cecidomyia sp.*) 1. Dorsal and ventral view of grub; *1a*, cocoon (*mag.*); *1b*, fly; *1c*, *1d*, enlarged antennæ of male and female insects; *1e*, immature galls on pine branch; *1f*, mature galls with pupæ *in situ* on branch. 2. *Trigonomerus sp.* parasitic on *Cecidomyia sp.*: 2, *2a*, dorsal and side views of fly; *2b*, magnified antennæ; *2c*, ventral and side view of pupa.

especially young plants, would appear to be affected in a similar way; but mature specimens of the insect have not been yet procured for identification. There can be little doubt that the pest is capable of committing considerable havoc.

The habit of blood-sucking from vertebrates is, among insects, of course confined to those with a suctorial mouth, and is exhibited by various *Diptera*. It is, however, indulged in by but a small number of species, and these do not belong to any special division of the order. The habit is as a rule confined to the female sex, and a large proportion of the species with this propensity have aquatic larvæ.

SERIES I.—*Orthorrapha Nemocera.*

Antennæ consist of more than six segments and are not terminated by an arista. Palpi slender and flexible, four or five-jointed.

FAMILY I.—*Cecidomyiidæ.*

These form an extensive family of very minute and fragile flies the wings of which are provided with only a few nervures; the antennæ are rather long and are furnished with whorls of hair upon them. In some species the antennæ are beautiful objects when seen under a magnifying glass. The larvæ are of importance as their habits are very diverse. They are short maggots narrowed at either extremity, with a small head and 13 segments. The majority live in plants and form galls, or produce deformations of the leaves, stems, flowers, buds, and roots in many ways. Others live under bark, whilst certain species are predaceous, feeding upon *Aphidæ* or *Acari*, or even other *Cecidomyiidæ.*

A member of this family, *Cecidomyia* sp., forms pseudo-galls on the branches of *Pinus longifolia*, these galls having a resemblance to young developing cones. The eggs are laid by the fly at the base of the bud scales at the end of the shoot. The young larvæ on hatching out feed upon the plant tissues and set up an irritation which causes the young needles to swell up and coalesce, thus forming a small gall. At the end of October these galls are about ¾ inch in length, ovoid, the scales being large with the margins turned outwards. They are covered externally with turpentine. The small orange grubs now crawl out and pupate, forming a white glistening cocoon on the outside of the gall or branch to which it is attached; the small, delicate, greyish, long-legged fly issues in February and March. This

fly is parasitised by a hymenopterous one, *Trigonomerus* sp. Fig. 284 (1) shows the maggots, cocoon, fly, and branches with pseudo-cones and cocoons, and 284 (2) the parasite.

The larva of another Indian species (*Cecidomyia oryzæ*) have proved very dangerous to rice, feeding in the stalk and killing off the plant. The insect known as the Hessian fly, *Cecidomyia destructor*, of Europe and America, is frequently excessively injurious to crops of cereals, committing at times the most serious depredations.

FAMILY II.—*Culicidæ* (Mosquitoes, Gnats).

Slender insects with very long legs, the antennæ being provided with whorls of hair or plumes on them, generally very long and dense in the male. The head is furnished with a long projecting proboscis. The larvæ live in stagnant water. They have a largely developed head and thorax, and so can be distinguished from other dipterous larvæ. The pupæ also live in water and move about in it.

Life-history of Mosquito.

Much has been written on the genera *Anopheles* and *Culex*, and it has been proved that species of the former can induce malaria fever in man. The larvæ live in water, floating flat upon the surface. The perfect insect is the well-known mosquito. The life-history is as follows:

The eggs are deposited on the surface of the water, where they float in raft-like masses. They hatch in a very short time, generally—in warm climates—within 24 hours, giving rise to small wriggling worm-like creatures, which feed either on minute water plants or on decaying organic matter. They breathe air, and must repeatedly come to the surface for that purpose. Their mouths are provided with a pair of brush-like organs which they keep in rapid motion, producing a miniature vortex which draws floating particles within reach of their jaws. After a period varying from 7 to 15 days during which time they undergo some four or five moults they assume the pupal stage, when their form is again changed. They now appear something like minute tadpoles or—still more—like animated, commas with a globular anterior portion and a thin curved tail. They take no food in this stage, but are very active, progressing through the water with a wriggling motion. Their breathing organs are now transferred to the front of their bodies and appear as small ear-like structures, and the insect rests in a more or less erect position, head upwards. In about three days' time the skin of the back splits and the mature mosquito emerges, resting upon the empty skin of the pupa as upon a raft, until its wings are firm and dry, when it flies off. Fig. 285 a, b, c, shows the larva, pupa and mosquito.

* *Vide* Royal Botanic Gardens, Ceylon. Circ. Ser. I, No. 25. "Mosquitoes and Malaria." E. F. Green.

The differences between *Culex* and *Anopheles* are well marked and may be shown as follows :—

Culex.	*Anopheles.*
Eggs: agglutinated into raft-like masses on the surface of the water. Each egg placed vertically.	*Eggs:* separate, floating horizontally on surface of water.
Larva: with long breathing tube at end of body. Floats head downwards.	*Larva:* without prominent breathing tube. Floats horizontally.
Adult insect: with palpi much shorter than proboscis. Wings usually clear and colourless. Rests with body parallel with support.	*Adult insect:* with palpi as long as proboscis. Wings usually spotted or clouded. Tilts the body at an angle to the support.

Thus by observing the position of rest taken up by the perfect insect on alighting upon one's hand one will be able to determine in most instances whether the insect is an *Anopheles* or not. The organism responsible for malarial fever is an animal organism named *Hæmamœba*. It is small and unicellular, and is found in the blood of a patient suffering from malarial fever. If left undisturbed the disease will be confined to this one man. If the latter is bitten by a certain kind of mosquito of the genus *Anopheles*, the mosquito takes in with the blood some of the *Hæmamœba*. These now undergo a true sexual cycle and the ♂ and ♀ parasites collect in the glands at the base of the proboscis of the mosquito. Should this latter then bite another person, the parasites are injected into his blood and thus go through their sexual cycle in him and induce an attack of malarial fever in him. It thus becomes obvious that persons suffering from malarial fever should be carefully protected from the *Anopheles* mosquito by means of mosquito curtains, etc., or they themselves become a centre from which others are infected.

FAMILY III.—*Tipulidæ* (Daddy-long-legs, or Crane flies).

These are slenderly built insects with very long legs; the wings have a system of nervures which is rather complex at the tips; there is a V-shaped suture on the thorax in front of the wings; an ovipositor is present. The family exhibits a great variety of forms, including the well-known stupid long-legged insects known as Daddy-long-legs. The sub-family Limnobiinæ contains species whose larvæ live under the bark of trees probably feeding upon the sap. In the tunnels bored by the longicorn larvæ of *Apriona Germari* in the Shahdera plantation, near Lahore, some whitish semi-transparent Limnobiid larvæ were found crawling about in the sap of the timber. The perfect insect has not yet been obtained.

FAMILY IV.—*Simuludea* (Sand Flies).

Small fat flies with humped back, rather short legs and broad wings, with short, straight antennæ destitute of setæ; proboscis not projecting.

There is only one genus, Simulium, of this family, but it is very widely spread and will probably prove to be nearly cosmopolitan. Some of the species are notorious for their blood-sucking habits, and in certain seasons they multiply to an enormous extent, alight on cattle in thousands, and induce a disease that produces death in a few hours.

Simulium columbaczense has occasioned great losses in this way near the Danube.

In India the family is represented by the well-known *potú* fly (*Simulium indicum*) (fig. 286) of the North-West Himalayas. This insect is plentiful in the summer in the chir (*P. longifolia*) and deodar (*Cedrus deodara*) forests of these mountains: the species found in Assam may be identical. It is most troublesome in the North-West Himalayan forests, as its bites are very irritating and produce blisters. The flight of the insect is noiseless and its bite at first so painless that the creature is seldom noticed until it has absorbed the blood from the wound. Brushing it away is then of no use. It leaves a characteristic mark due to the presence of a little globule of blood, about the size of a pin's head, beneath the skin. This rapidly turns black. The irritation produced varies in intensity in different people, but the insect has been known to drive whole camps of sawyers from the forest and to stop all work.

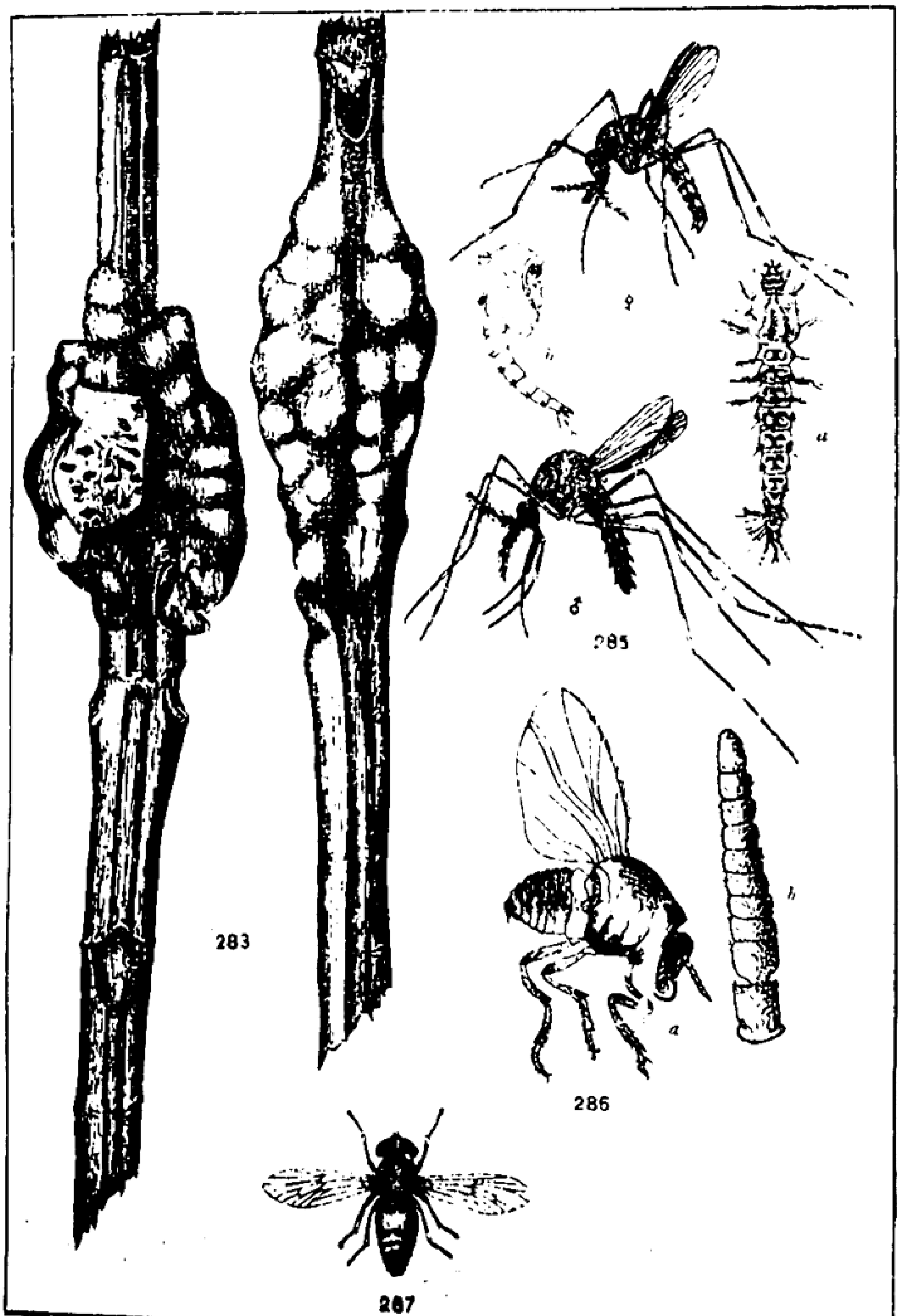
Life-history of *Potú fly*.

SERIES II.—*Orthorrapha Brachycera.*

Antennæ variable. Palpi only one or two-jointed. The system of nervures in the wings is complex and there is no definite arched suture round the insertion of the antennæ.

FAMILY V.—*Tabanidæ* (Gad-flies).

The proboscis in this family is fleshy and projecting, the antennæ are said to be three-jointed, but the last joint is constricted, and therefore they consist of apparently more than three joints. The head is short and broad, with very large eyes; mandibles (biting jaws) are only present in the ♀; the abdomen is flattened; the larvæ are cylindrical, some of them being aquatic, others living in the earth or in decaying wood; they are of predaceous habits, attacking and sucking insect larvæ or worms. The female flies suck the blood of mammalia and are a great plague to horses, cattle, and animals of all sorts in India.



283. Galls on Teak branches made by *Cecidomyia sp*

285. A Mosquito (*Anopheles*). *a*, larva; *b*, pupa; *c*, male and female insect (*a* and *b* after E. E. Green).

286. The Potû fly (*Simulium indicum*). *b*, enlarged antenna.

287. Assam Elephant fly (*Nemocera* (?) *sp.*)

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Species of this family are very plentiful in India, and the large horse-flies of the forest are well known to all foresters. It is these insects which drive large game, such as elephants, sambhur, etc., living at the foot of the Himalayas and other mountain ranges, to seek the higher hills, and consequently cooler climate, during the hot weather months, at which season the flies are particularly abundant. Fig. 287 shows the fly Nemocera sp. of the Assam evergreen forests.

FAMILY VI.—*Bombyliidæ*.

The body is frequently fringed with down or covered in large part with hair. The legs are slender, claws being small, with only minute pulvilli. Proboscis very long and moderate, antennæ three-jointed, terminal joint not distinctly divided, sometimes large, sometimes hair-like. This is a large family of flies and is of great importance to both naturalist and economist. There are two well marked types of fly in the order: (1) the *Bombyliides* with very long exserted rostrum and humped thorax; and (2) *Anthracides* with a short beak and of more slender thorax and graceful form. None of these flies are blood-suckers; they frequent flowers only and use their long rostrum in a harmless manner. The wings are usually ornamented with a pattern, and the clothing of the body is frequently variegated. It has recently been discovered that the larvæ of various species of *Bombyliidæ* are of great service in that they devour locust eggs, whilst a species of *Systropus* has been recorded as destroying the larvæ of *Limocodes*.

FAMILY VII.—*Asilidæ* (Robber-flies).

This is one of the largest families of flies, including over three thousand described species. In these flies the mouth forms a short, projecting, horny beak, the palpi being small. The body is elongate and hairy, and the feet have powerful claws which are often thick and blunt. The insects are predaceous in the winged state and devour numbers of other insects They prey upon large species and fear none, attacking wasps and other stinging insects and capturing even dragon-flies and tiger-beetles. Little is known about their larval stages in India.

SERIES III.—*Cyclorrapha Aschiza.*

Antennæ with not more than three joints, and these are furnished with an arista, which is not terminal. Front of head has no definite arched suture over the antennæ.

FAMILY VIII.—*Syrphidæ* (Hover-flies).

Flies of moderate to rather large size, frequently spotted or banded with yellow, having very short, three-jointed antennæ and a cleft on the under side of the head in which the proboscis, which is thick and fleshy, can be withdrawn. This family is one of the largest and best known of the flies. Species abound in gardens and glades of the forest where in sunny weather they may be seen hovering over flowers or in the rays of sunshine which pierce through the leafy canopy of the trees. The larvæ are very diverse in appearance, and they live either on plants or in water. Some feed upon aphidæ or plant lice, and they may then be found on bushes or trees attacked by these blights, devcuring them with great voracity and in large numbers.

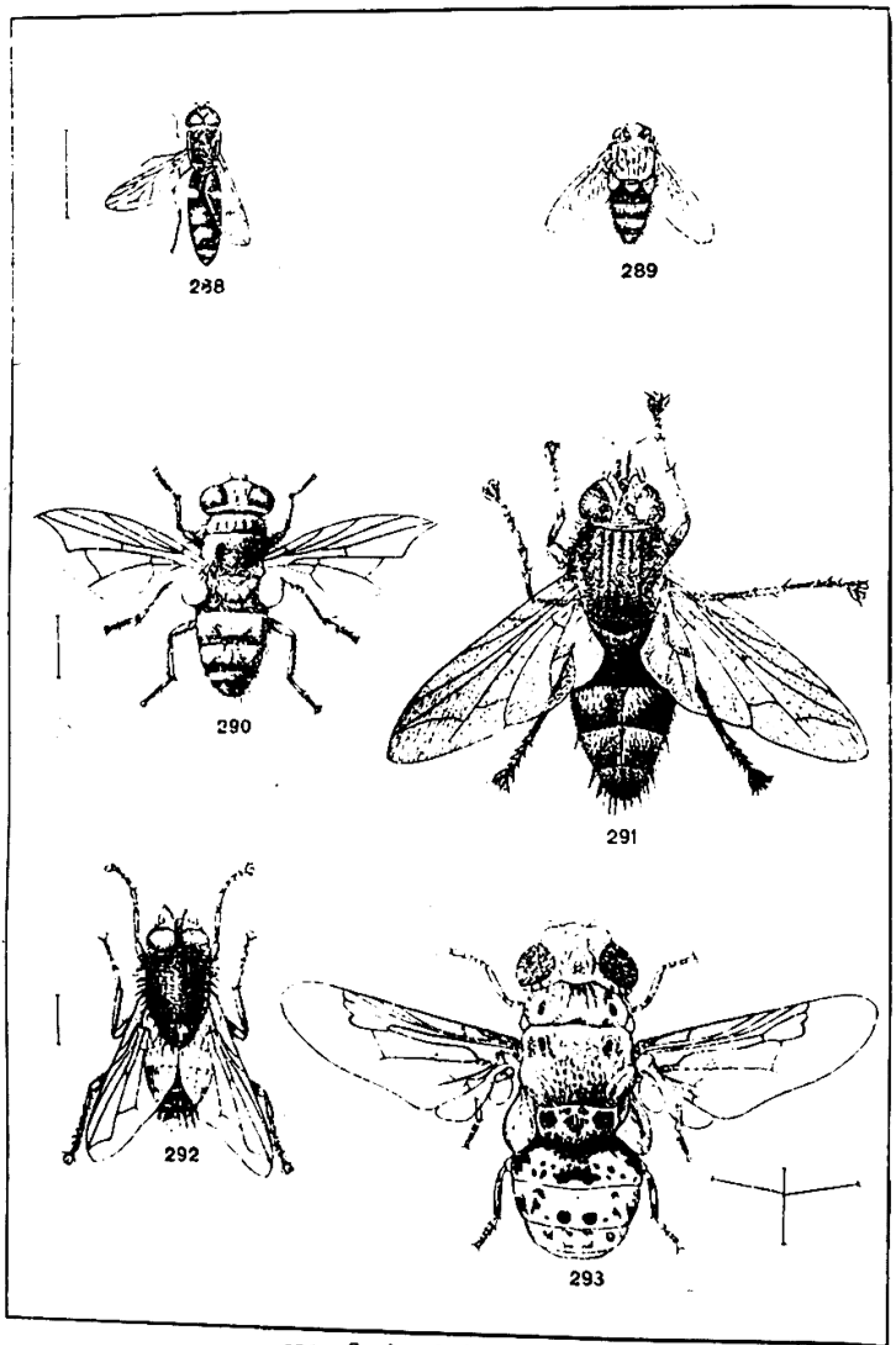
The larvæ of *Syrphus nietneri*, Schiner and *Syrphus splendens*, Dolesch (fig. 288) are said to prey in this way upon the coffee louse, *Aphis coffeæ*, in Ceylon.

SERIES IV.—*Cyclorrapha Schizophora.*

Antenna has three joints and is furnished with an arista. The frontal suture over the antennæ is often well marked. The nervures in the wings are not so complex.

FAMILY IX.—*Tachinidæ* (Parasitic-flies).

This is an enormous family of flies, the larvæ of which live parasitically on other living insects, Lepidopterous caterpillars being especially attacked. The antennal arista is bare and thus these insects may be distinguished from the house-fly, in which it is plumose, and the upper surface of the body is bristly. The insects of this family have in many cases a very great resemblance to the common house-fly. Many have been reared from the insects in which they live, but beyond this little is known of their life-histories. The eggs are usually deposited by the flies near or on the head of the host. The grub on hatching out burrows into the caterpillar's body, but avoids



288. *Syrphus splendens.*
289. *Mascicera sp.*
290. *Mascicera dasychira.*
291. *Trycolyga bombycis.*
292. *Musca domestica.*
293. Common Bot-fly of the Camel (after Sharp).

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the vital organs, so that the parasitised larva usually lives on until the dipterous grub is full fed, and it may even change into a pupa before death ensues. In the latter case the pupa will be found to contain one or more small fly pupæ, according to the number of eggs laid upon or in, and developed in, the caterpillar. No moths will of course issue from pupæ attacked in this way. If the caterpillar dies before changing to the pupal state the fly-maggots will cut their way out and change into pupæ on the outside alongside of the dead caterpillar's skin, or they may burrow into the ground and pupate there. From the above it will be seen that these flies are of the very greatest importance and service to man, owing to their habit of destroying caterpillars, and thus keeping down swarms of defoliating larvæ.

We are only just at the commencement of our researches in this respect in India, but there can be little doubt that these insects will well repay study.

Life-history of Masicera sp., the Teak defoliator parasite.

The writer has bred a new species of *Mascicera* (fig. 289) from the caterpillars of the destructive teak tree defoliator *Hyblæa puera* in the Nilambar Plantations. Flies issued in September from caterpillars parasitised in August. *Mascicera dasychirae* (fig. 290) parasitises the Sal Defoliators Dasychira horsfieldi and some or all of the species of Lymantria which defoliate this tree in Assam.

Members of the family are a serious nuisance to silkworm research, as unless especial precautions are taken they destroy the worms wholesale. *Trycolyga bombycis* (fig. 291) is parasitic upon the Eri and mulberry silkworms of Bengal and is very destructive. It is very like a large house fly in appearance. It in its turn is parasitised by a smaller fly named *Phora cleghorni*, which attacks it in much the same way it attacks the silk caterpillars.

A closely related family *Anthomyiidæ*, which has much the same characters as the *Tachinidæ*, contains the important fly *Anthomyia peshawarensis*, which is parasitic upon the eggs of the migratory locust *Acridium peregrinum*.

FAMILY X.—*Muscidæ* (House-flies).

The arista is feathered, and by this they can be distinguished from the Tachind flies which they otherwise resemble. This family contains many of the most abundant species on the face of the earth, including the house-fly, blue-bottles or blow-flies, and other forms. The larvæ live on carrion and decaying or excrementitious matter.

Life-history of Musca domestica.

The common house-fly (*Musca domestica*, fig. 292) runs through its life-history in a very short time. It lays about 150 very small eggs on dung or any soft damp filth; the larvæ hatch out in a day or two and

feed on refuse; they may be full grown in five or six days and then, pupating may emerge in another week as perfect flies. This accounts for their enormous and rapid increase where dirt and decaying matter is abundant. It has been calculated that one female of the common house-fly may have 25,000,000 descendants during one season.

The grubs of the fly *Rivellia persicæ* have been reported as seriously affecting the growth of the peach (*Prunus persica*) fruit in Chota Nagpur, whilst those of *Dacus ferrugineus* live in and considerably damage mangoes.

FAMILY XI.—*Oestridæ* (Bot-flies)

This is a small family of flies, the larvæ of which live in the bodies of vertebrates. The insects are large flies with very short antennæ bearing a segmented arista; the front of the head is prominent, and the posterior part of the wings is often rough and with very few veins. The family is of small extent, less than 100 species being known, yet it is of interest owing to the habits of its members. Some (*Gastrophilus*, etc.) live in their larval stage in the alimentary canal; others (*Hypoderma*, etc.) are encysted in or under the skin while others (*Oestrus*, etc.), occupy the respiratory passages. Many of them attack the domestic animals used by man, and some even man himself. The life-histories are still very incompletely known. They do not bite the animals they attack, but deposit the eggs upon the hair of the skin or the young larvæ, already hatched, in the entrance of the nasal passages. The larvæ always quit the bodies of their hosts to pupate.

Horses, oxen, deer, sheep, etc., are attacked by these flies. Fig. 293 shows the common bot-fly of the camel.

SERIES V.—*Pupipara.*

Often wingless flies or the wings are reduced in size. The young are produced alive, full grown, but have still to undergo a metamorphosis. They are found in connection with vertebrates, and the habit of blood-sucking is probably common to both sexes.

FAMILY XII.—*Hippoboscidæ.*

The wings are variable, sometimes present and large when the surface is waved and the nervures are thick and confined to the

anterior and basal part, at other times mere strips, whilst occasionally they are entirely absent. The proboscis differs from that of other flies, consisting of two hard flaps fitting close together, which can be opened allowing an inner tube to be exserted from the head. The family includes the horse-fly and the sheep-tick.

NOTE.—The sub-order Aphaniptera includes the Family Pulicidæ or fleas which are wingless insects, having the body laterally compressed, so that the transverse diameter is small and the vertical one great It is unnecessary to do more than mention these insects here. They are known to all.

USEFUL DIPTERA.

The Order contains some insects whose habits render them of the greatest use to man. Amongst the *Cecidomyiidæ*, a family containing some bad pests, there are some species which are predaceous, feeding actively upon *Aphidæ* or *Acari*, and even upon their own relatives. The larvæ of the *Tabanidæ* are predaceous in habits, feeding upon other insect larvæ and worms. It has been descovered that some species of the *Bombyliidæ* are of great service, in that they devour locust eggs, whilst one has been recorded as destroying the larva of *Limacodes*. As the adults of this family frequent flowers, it is probable that they are of some service as pollen distributors.

The *Asilidæ* are predaceous in the winged state and devour numbers of other insects, attacking all species without fear. They probably do some harm in this way by attacking useful species, it being known that they will feed upon useful predaceous tiger-beetles and dragon-flies.

Some of the larvæ of the *Syrphidæ* are known to feed upon *Aphidæ*, whilst the family *Tachinidæ* include almost entirely parasitic species which feed within other insects, chiefly perhaps the carterpillars of *Lepidoptera*. The *Amthomyiidæ*, a closely-related family, contains the important fly *Anthomyia peshawarensis*, which is parasitic upon the eggs of the migratory locust of India, and thus renders great service to man by checking to some extent the increase of this pest.

ORDER VIII.—THYSANOPTERA (Thrips.)

These are extremely abundant minute insects, which are to be found in profusion in flowers. They have four very narrow fringed wings and an imperfectly suctorial mouth. They are, as far as our present knowledge goes, of no importance to the forester, though species have been reported as injurious to turmeric, the opium poppy, and the leaves of the tea plant. It has been said that some feed upon *Aphidæ*, but the statement does not appear to be supported by sufficient evidence at present to render it of importance.

CHAPTER X.

ORDER IX.—HEMIPTERA OR RHYNCHOTA.

The *Hemiptera* or Bugs are perhaps better known as Rhynchota. They are insects whose mouth parts consist of a proboscis or beak (usually concealed by being bent under the body) which has the appearance of a transversely-jointed rod or sheath, in which are enclosed long slender processes like horse-hairs which are used for piercing plant substances. (See fig. 42.) The possession of this form of mouth renders it easy to distinguish the insects of this order. The Lice, which belong here, have not this jointed beak; these will be referred to later on. The Hemiptera are without exception sucking insects, and the mouth parts of the individual are of one form throughout life, there being no pupal stage in the order. The thorax is always very distinct, and often large, both the meso- and meta-thorax being well developed, and the scutellum of the former is frequently very large, at times covering the entire dorsal surface of the body. The wings are usually four in number. The upper half of the upper wing is in some cases horny, the wings then shutting flat on the back; or they may be membranous and fold on the back in a roof-shaped manner. The young resembles the adult in general form; the wings are developed outside the body, by growth at the different moults. There is often an ovipositor in the female.

About 18,000 species have been described, and there is probably no order of insects which is so directly connected with the welfare of the human race as the *Hemiptera*: it is probable that if anything were to exterminate the enemies of the Rhynchota, man himself would be starved off the face of the earth in a short period. Their operations escape observation to a large extent, as they merely make pricks in the food plant and then suck away its sap without in many cases leaving any very evident marks of their former presence. Thus nothing being observable, injuries really due to Hemiptera are often attributed to other causes.

For our purpose we will divide the order into the two sub-orders Heteroptera or true Bugs and the Homoptera which includes the scale insects, cicadas, blights, etc.

SUB-ORDER I.—HETEROPTERA.

Front of head does not touch the coxæ (hips). The anterior wings are more horny than the posterior pair and fold flat on the back, their apical portions usually more membranous than the bases which are horny. The lower portion of the right wing overlaps the left at tip.

FAMILY I.—*Pentatomidæ.*

This is the largest family of the Heteroptera, including some 4,000 species. The insects can be recognised by the large scutellum which is at least half as long as the abdomen, and often covers the whole of the after part of the body and wings. Antennæ are often five-jointed and the proboscis sheath is four-jointed. The ocelli are two in number and there is an appendage to each tarsal claw. The colouration in these insects is often very vivid This family contains a number of pests and one or two useful predaceous insects.

Life-history of *Ocrophara montana.*

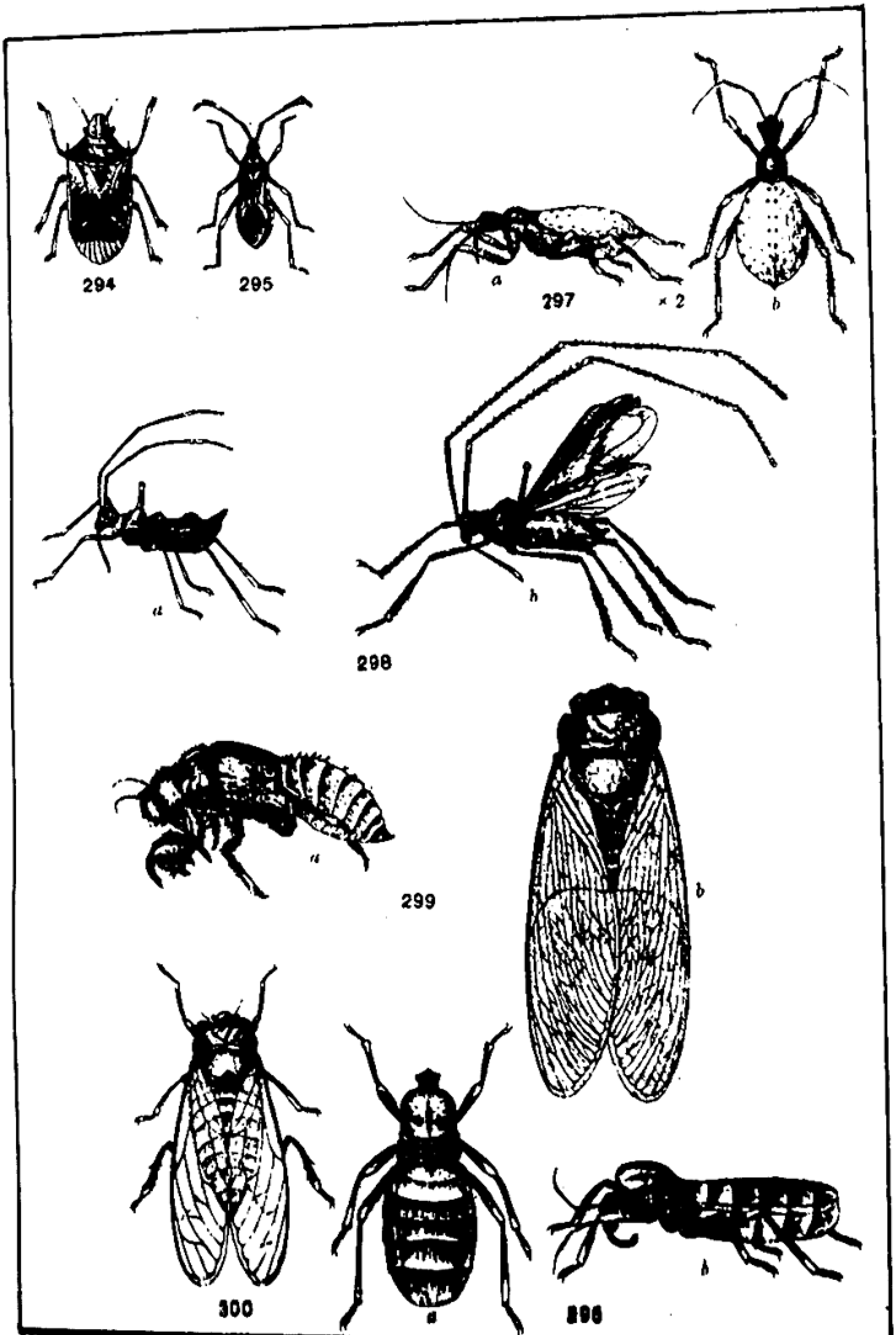
An insect named *Ocrophara montana* (see fig. 294) or the bamboo bug has proved a serious pest to bamboo seed.* The following is known about its life-history :—
The insect feeds in both larval and adult stages upon the developing seed of the bamboo, *Dendrocalamus strictus.* In 1900 it appeared in the Central Provinces in enormous numbers in the middle of January and fed voraciously upon the ripening seed till the middle of March and then disappeared, having probably laid its eggs somewhere first. Nothing further appears to have been recorded on the life history of this pest.

Canthecona furcellata is a small active yellowish bug which is said to destroy tussar silkworms. It probably also feeds upon noxious defoliating caterpillars.

FAMILY II.—*Coreidæ.*

The members of this family are easily recognised by the following characters :—The scutellum is smaller than in the last and does not reach to the middle of the body; the proboscis sheath is four-jointed and ocelli are present; antennæ are generally elongate and four-jointed and are inserted on the upper parts of the sides of the head; the femora of the legs are not knobbed at the tip.

* *Vide* Departmental Notes on Insects which affect Forestry, Vol. I, p. 123, for a fuller account.



294. *Ochrophora montana.*
295. *Ceratopachys variabilis.*
296. *Physorhynchus sp.*
297. *Reduvius (?) sp.*
298. *Helopeltis theivora.* a, larva; b, winged insect.
299. *Common Mussoorie Cicada.* a, empty full-grown larval skin; b, winged insect.
300. Common green grass Cicada of Assam.

[to face page 154.

These insects are rarely of brilliant colours.

The family includes a very destructive species in India known as the Rice-sapper.

An insect known as *Ceratopachys variabilis* feeds upon the Jhand (*Prosopis spicigera*) in the Punjab and has the following life-history :* –

Life-history of *Ceratopachys variabilis*.

The bugs commence feeding in February, having hibernated through the cold weather months as half grown larvæ, and become full grown in March. They then pair and eggs are laid, and the next generation takes about ten weeks to pass through : two weeks being spent as a wingless larva, two with rudimentary wings, and three whilst these rudimentary wings are becoming fully developed. The number of summer generations has not yet been ascertained. The insect finally hibernates at the beginning of November. The eggs, when first laid, are of a brilliant green colour, which soon turns to reddish brown. The insect itself is green and red in colour. It appears to confine its attacks to one-year old coppice shoots, sucking out the sap from them. The shoots turn yellow and dry up, the growth thus being retarded one or more years by the attacks of the insects ; fig. 295 shows this bug.

FAMILY III.—*Lygæidæ*.

The characters of the members of this family are the same as those of the Coreidæ, the insects only differing in the position of the insertion of the antennæ ; the upper surface or face of the insect is not flat, but is transversely convex, so that when seen in profile the antennæ appear to be inserted well down upon the sides of the head. The family contains some injurious insects. Most of the known Indian species are reddish in colour, as, *e.g.*, the red cotton bug and other plant-feeding forms.

Little is at present known about the forest living members of the family.

FAMILY IV.—*Reduviidæ*.

These insects are easily recognisable by their freely movable elongate head and by the short curved scimitar-like proboscis which does not extend on to the breast. They can at times inflict a wound with this proboscis. The eyes are placed much in front of the thorax and the ocelli when present are situated behind the compound eyes. The insects are only of importance owing to their predaceous habits. They feed upon other insects and probably destroy large numbers of injurious forms. Some members of the family live under bark and feed

* *Ibid*, p. 126.

upon wood and bark-boring beetles. A species has been found engaged in this manner under spruce bark in the North-West Himalayas.

Physorhynchus sp. (fig. 296) is a large black species common in Jaunsar, N.-W. Himalayas. Reduvius sp. (fig. 297) lives beneath the bark of *Nauclea sessilifolia* trees in Burma and preys upon bark-boring insects.

FAMILY V.—*Capsidæ.*

These are moderate-sized or small bugs of delicate consistence. They have no ocelli present. The elytra and wings are usually large in proportion to the body. Antennæ are four-jointed, the second joint being usually very long and the terminal two more slender than the others. There is no groove on the under surface or the proboscis to fit into. The scutellum is exposed and moderately large and the tarsi are three-jointed. The female has an ovipositor which she can put out and draw in at will. The family is a large one, the insects being delicately coloured and never metallic. They frequent plants of all kinds, and many of them skip, by the aid of their wings, with great agility in the sunshine. The majority suck the juices of plants, but some are known to prey upon other insects.

The best known Indian genus is *Helopeltis* to which the mosquito blight of tea belongs. These insects possess a knobbed spine projecting straight up from the scutellum. The egg is placed by the bug in the stems of the tea-plant, but attached to one end of the egg are two long slender threads which project externally. The insects on hatching out suck up the juices of the plant. They appear on the plant all through the spring, summer, and autumn months. Fig. 298 shows the young stages and the full-grown insect.

Disphinctus humeralis Wlk. is a small insect which has been reported as attacking chincona in Sikkim. Little seems to be at present known about it.

NOTE.—The various bugs which live in water, known as *Cryptocerata,* belong to this sub-order. They are provided with swimming legs.

SUB-ORDER II.—HOMOPTERA.

The front of the head is much inflexed so as to be in contact with the coxæ. The anterior wings are of the same consistency throughout, and do not overlap at the tips. This sub-order is divided into three series according to the number of tarsal joints present on the feet of the insects—the *Trimera* having three, *Dimera* two, and *Monomera* one tarsal joint, respectively.

SERIES.—*Trimera.*

Tarsi usually three-jointed.

FAMILY VI.—*Cicadidæ* (Cicadas).

These insects, as far as is at present known, are seen above ground only in the perfect condition, spending the earlier larval stage in the soil upon roots. They can be recognised by having a head with three ocelli placed triangularly upon the summit between the compound eyes; the antennæ consist of a short basal joint surmounted by a hair-like process divided into about five segments. The front femora are more or less thickened and are armed with teeth. The family consists of large insects with the four transparent and shining wings, the nervures being distinct and dark-coloured. The insects are sometimes brightly coloured, black and yellow being the predominant tints. The body is broad and robust. They are mostly tropical insects. The Cicadas produce the curious whirring sound which is so characteristic of the submontane and montane forests in India. The sound is produced by the male by means of a specially modified stigmata which can be seen at the base of the hind-legs. The eggs are in the case of some species laid by the female in the branches of trees in which she makes incisions with her ovipositor. On hatching out the young larvæ crawl down to the ground and bury themselves in the earth where they feed upon the roots, and in this manner may spend several years in this stage of their existence. They usually, if not always, leave the ground before the last moult or shedding of the last skin, this being often done upon the trunks of trees, etc. After shedding this last skin the insects are fully developed; they then pair and lay eggs. The life-histories are little understood, but Cicadas appear at intervals in swarms rather after the manner of the appearance of the north-west locust over India.

In India there are numerous species, but practically nothing is known about their life-histories. Fig. 299 *a b*, shows the empty last larval skin and full-grown insect of a species of Cicada common round Mussoorie; fig. 300 a Cicada common in the great grass jungles of Assam. It is bright green in colour.

FAMILY VII.—*Fulgoridæ.*

These insects can be best distinguished by the fact that the two ocelli present are placed beneath the eyes or near the eyes usually in

cavities of the cheeks. The antennæ are placed beneath the eyes and are very variable in form, usually consisting of two joints terminated by a very fine hair. The prothorax is not armed with spines, etc., and is of normal size. Some of the insects are very large, others quite small. The family includes the so-called Lantern-flies in which the front of the head forms a huge misshapen proboscis which was formerly believed to be luminous. Many of the species are of bright colouration. A number have the power of excreting large quantities of a white, floculent wax.

One of the commonest members of this family in many parts of India is *Phromnia marginella*. The mature insect resembles a moth, the parchment-like front wings being grass green with the anterior margins red, the posterior wings milk white, and the body greenish. Round Dehra Dun, where the insect is common, the eggs are laid in numbers in the bark of twigs and hatch out in December-January, and the larvæ may be found clustering in white masses on the food plant from then until the commencement of the rains. The larvæ are covered with a mass of white floculent matter, secreted by small glands on the back of the abdomen. This as they get older stretches out behind in long, white, tail-like appendages, rendering the insect unmistakable. They appear to feed on a variety of trees. Fig. 301 a, b, c shows the young larva, imago, and a leaf with larvæ clustered on it.

Life-history of *Phromnia marginella.*

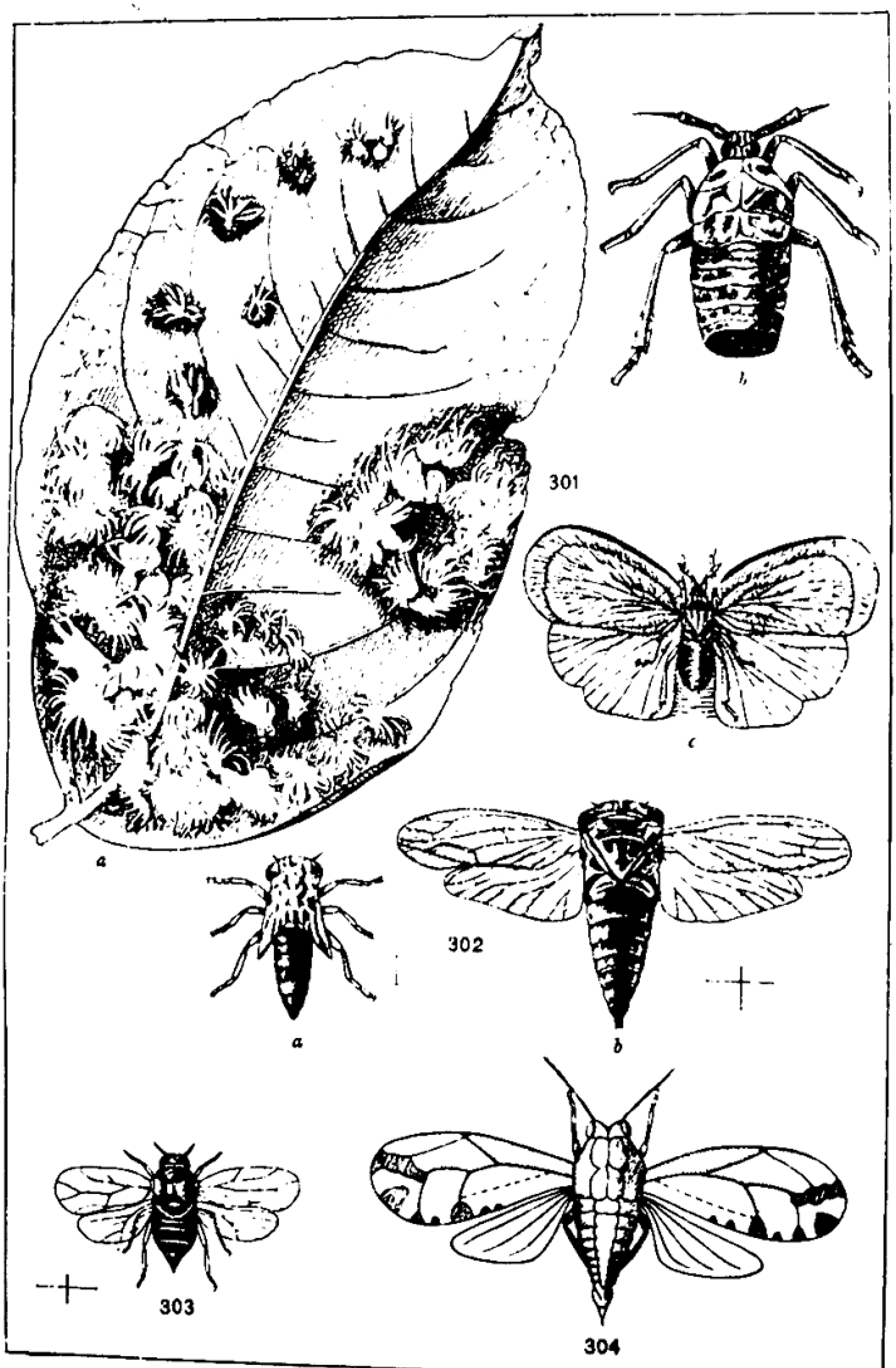
A large typical fulgorid was plentiful on the teak in the South Coimbatore forests in July 1902. Its history, which is likely to prove interesting, requires working out.

FAMILY VIII.—*Membracidæ.*

This family is of large extent, its members being chiefly tropical, and are especially abundant in America, and probably so in India, but little is known about them in this latter country. The insects are of curious form; the prothorax is prolonged backwards into a hood or processes of various shapes; the antennæ are inserted in front of the eyes, and there are two ocelli placed between the eyes. The young have but little resemblance to the adults, the great thoracic hood being absent, while on the back there is on each segment a pair of long half-erect processes having fringed margins.

FAMILY IX.—*Cercopidæ.*

There are two ocelli (occasionally absent) which are placed upon the vertex; the antennæ are placed between the eyes. The thorax is not peculiarly formed.



301. *Phromnia marginella.* *a*, young larvæ on a leaf; *b*, empty skin of full-grown larva; *c*, winged insect.
302. *Idiocerus niveosparsus.* *a*, young larva; *b*, winged insect.
303. *Psylla cistellata.*
304. *Phacopteron lentiginosum.*

[to face page 158.

These insects are the common cuckoo-spits, so called from the habit of the larvæ of emitting a liquid which it secretes in large amounts in the form of bubbles which accumulate round the insect and conceal it. The adults are known as frog-hoppers, their power of leaping being very great. Circopidæ are common on the leaves of many trees in Indian forests, though at present very little is known about them.

The eggs are laid upon the food plant, and the insect lives upon it in all its stages.

A species belonging probably to the genus Machœrota has been reported as making 'webs' on the farash *Tamarix articulata.*

A large cuckoo-spit in its typical froth bubble was plentiful on the teak in the South Coimbatore forests in July 1902.

FAMILY X.—*Jassidæ* (Cicadellinæ).

A large number of small or minute insects are included here. The insects are usually of narrow parallel form and frequently excessively delicate and fragile. Ocelli are two in number, placed just on the front margin of the head (almost in a line with the front of the eyes, or more in the front) or on the deflexed forehead. Hind tibiæ usually with many spines.

The mango jassids, of which three species—*Idiocerus niveosparsus, I. clypealis* and *I. atkinsoni*—are known, suck the juices, of the young shoots, young leaves, and flowers of mango trees, at times to such an extent that light crops of fruit are the result. Fig. 302 a, b shows the young larva and full grown insect.

A species of jassid has been reported as very numerous in the Godaveri teak forests where it apparently causes the leaves to wilt and wither.

SERIES 2.—*Dimera.*

Tarsi usually two-jointed.

FAMILY XI.—*Psyllidæ.*

Minute insects with usually transparent wings placed in a roof-shaped manner over the body; three ocelli are present and the antennæ are long and thin, consisting of eight to ten joints. Very little is known about the Indian forms of this family. They are sometimes called springing plant lice as their habit of jumping distinguishes them from the

Aphidæ. They vary remarkably in colour, the latter apparently depending upon the age of the individual, the food plant, the climate, and more particularly the season of the year. The insects probably pass through several generations in the year. The young larvæ differ in form from the adult. Psyllidæ excrete or exude from their bodies matter which is sometimes called honeydew; these exudations are often in large quantities, the substance running down from the trees on to the vegetation beneath.

An insect, named *Psylla cistellata*, attacks and aborts mango shoots (see fig. 303), whilst another, *Phacoptera lentiginosum*, (fig. 304) forms galls upon the *Garruga pinnata*, and a third, *Psylla obsoleta*, galls on *Diospyros melanoxylon*. *P. obsoleta* is a small winged fly ferruginous in colour with a single pair of

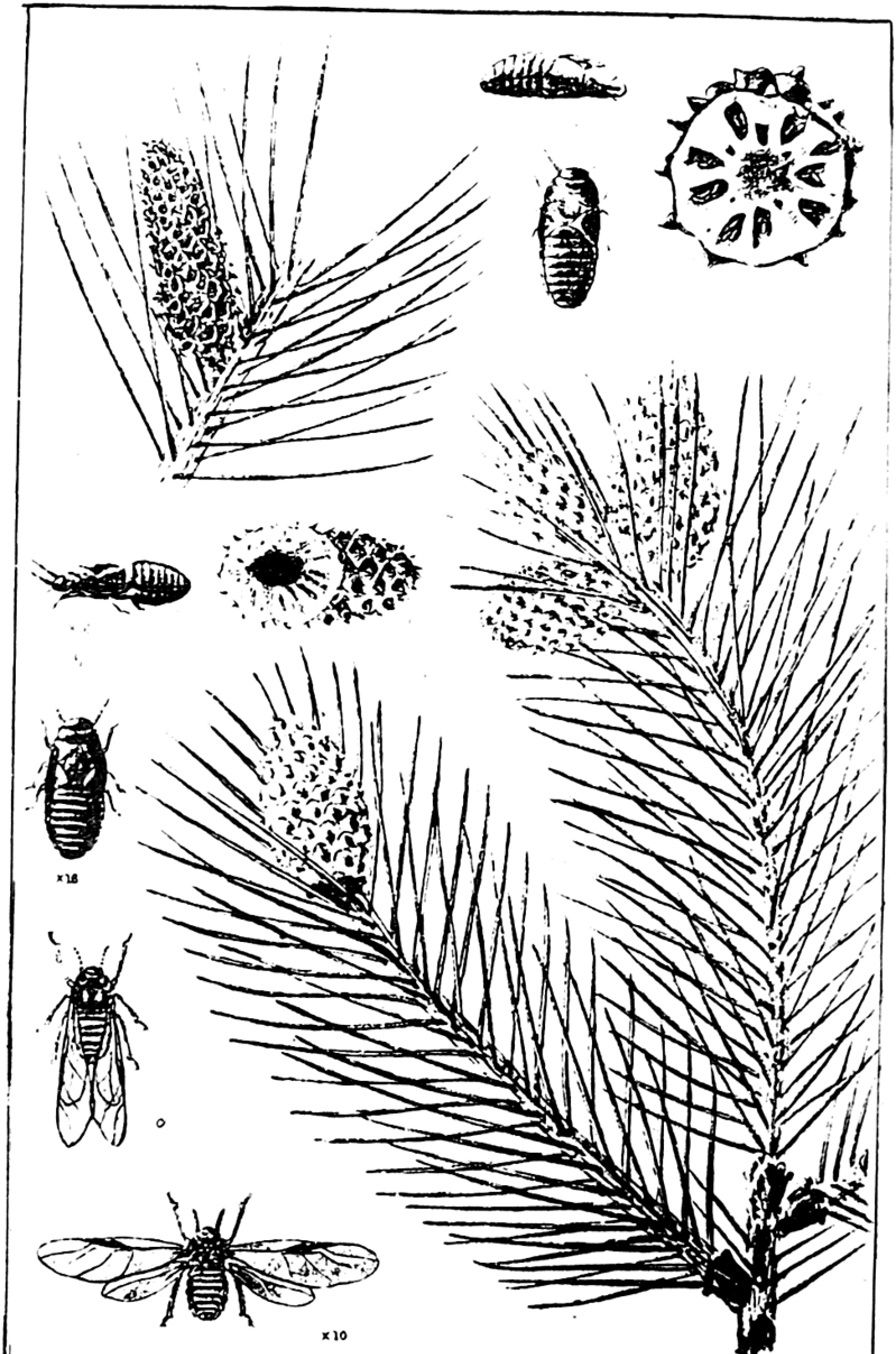
Life-history of *Psylla obsoleta*.

transparent wings. The galls are formed by the young insects collecting together and sucking the juices from the leaf. The irritation set up, gives rise to a yellowish red rough swelling having the appearance of the gall known as 'oak-spangles' in England. The insects mature and quit the gall in January. The insect appears to attack only the leaves of young plants 6—7 years old.

FAMILY XII.—*Aphidæ* (Blights, Plant lice).

A large family of minute insects which are extremely injurious to vegetation, and are proving themselves to be destructive pests in Indian forests. As usually met with they are destitute of wings although many species have two pairs of transparent wings which have a very characteristic neuration. In the wing there is one main nervure which forks, and from the fork another forked vein is given off. This is characteristic of the Aphid wing. The antennæ are long or moderately so, and are from three to seven-jointed. The body is soft, often bulky, pear-shaped, and green, yellow, brown, or black in colour. The surface is often covered with waxy blooms. The abdomen has often a pair of tubes or short processes upon the upper side of the fifth abdominal segment which secrete saccharine solutions. The legs are feeble and the wings are often absent in the females. The first joint of the two-jointed tarsus is sometimes very short.

These thin-skinned insects are sometimes called 'blight,' and during the warm months of the year they are capable of increasing in enormous numbers. This is due to peculiarities in their life-histories, which render this family a very important one in the eco-



305. *Chermes abietis piceæ*, Steb., *a*, *b*, larvæ, *c*, winged insects; *d*, pseudo-cones on spruce containing larvæ; *e*, section of a cone showing chambers containing larvæ; *f*, same enlarged; *g*, empty gall from which larvæ have swarmed.

[to face page 166

nomy of nature. An Aphis is injurious owing to the enormous amount of sap it extracts from the plant on which it feeds, and also owing to the fact that it clogs up the stomata of a plant with the saccharine solutions which it exudes. A fungus often arises from this sticky solution; *e.g.*, in the case of the Bamboo Aphis, which is common in India, a black fungus grows in the sweet matter it exudes and forms a felt-like mass on the stems.

The eggs are often laid on the plant in the autumn and remain there till the spring, when there hatch out from them wingless females which do not lay eggs but produce young parthenogenetically. This goes on till the autumn, the young reaching maturity in a week or ten days under favourable circumstances, and bearing young parthenogenetically in their turn, the insect thus multiplying exceedingly rapidly and in very large numbers. In the autumn the last brood produced are males and females, the latter being usually wingless. These pair and eggs are laid. The winter is passed through in this stage, and the wingless stem mother hatches out in the succeeding spring. The life-history is sometimes varied by some of the females of the last generation having wings. These may then fly off to another plant, and lay their eggs on it. This occurs in the case of the insect known as *Chermes abietis-piceæ* whose life-history we will shortly consider.

Life history of *Chermes abietis-piceæ*, Steb.

This *Chermes* lives upon spruce and silver fir in the North-West Himalayas. The winter is passed through by the stem mother, who takes shelter at the base of the shoots of the spruce and can be found there in the spring, her proboscis buried in the bark of the shoot. She lays a number of eggs here, and these hatch out into larvæ, the minute purple larvæ shown in fig. 305 a, b. The irritation caused by their feeding at the bases of the young needles gives rise to a gall formed by the young leaves swelling up at their bases, the young larvæ becoming enclosed in chambers within it (fig. 305 f). The larva grows to full size in the gall which consists of a number of chambers having several larvæ in each, and by the time the gall is ripe in the summer (July) they are ready to issue The scales or covers of the cone-like gall contract, one end curling up and thus forming an opening through which the larvæ crawl (fig. 305 g). Their last larval skin then splits down, and the mature insect walks out. Its wings, which are in little rolls on its back, open out under the influence of the sun and heat and soon become hard and the insect then flies off. The effect of this gall is to cripple the shoots (fig. 305 d.) The insects which leave the galls are winged females, and a certain number of them migrate to the silver fir upon which they lay their eggs, which are covered with a cottony deposit. The males

pair with the females, and from the sexually produced eggs laid arise the stem mothers. The stem mother from the portion of the generation which flew to the silver fir probably lives through the cold weather under the bark and appears in the spring. The larvæ hatching out in May from the eggs she lays spread over the needles and suck out the sap from them. They can be seen on the bright green young needles in the spring as minute purple black dots exactly resembling the small grubs in the spruce gall. Under their attacks the needles of the silver fir often become contorted and twisted into a spiral kind of cone. Towards the end of June these grubs become full grown and casting off the last larval skin become fully developed flies resembling those issuing from the spruce galls (see fig. 305 c). These winged individuals fly to the spruce and lay eggs upon it. Thus we have two generations of the same insect feeding at different times on two different host plants, and we get the phenomenon known as parallel series.

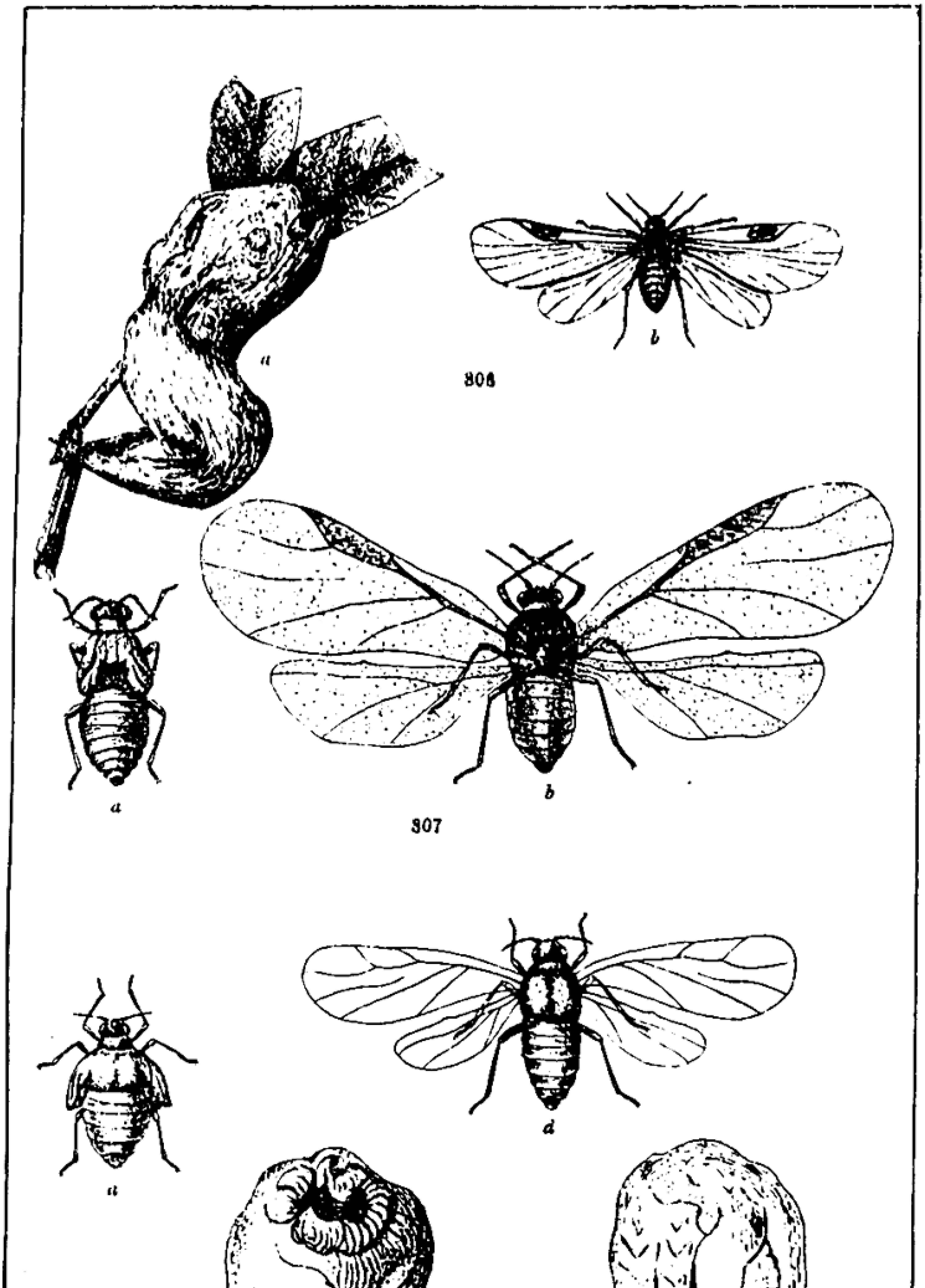
In Europe a well-known instance of this is provided by the insect *Chermes abietis-laricis* which forms the well-known pseudo-galls upon the spruce during one of the generations or series, whilst the other is spent upon the larch. In the North-West Himalayas these galls on the spruce differ from the European ones in that the upper part of the branch does not continue to grow out of the top of the cone.

A black aphid seriously attacks the blue pine in the North-West Himalayas and causes very heavy defoliation to the tree owing to the large amount of sap which it takes from the branches in the spring and early summer. This insect sometimes swarms so thickly on the branches as to entirely enclose them in a winged black mass of aphids.

Life-history of the Pemphigus gall-makers.

The genus *Pemphigus* contains other gall-producing aphids. *P. edificator* produces galls upon the twigs of *Pistacea terebinthus* in Baluchistan. These galls are as much as 4 inches in length, and a tree may contain a number of them. The flies are black in colour and issue in November. Fig. 306 shows the fly and gall. *P. napæus* (fig. 307) and *P. immunis* (fig. 308) form galls on the twigs of poplar trees (*Populus euphratica* and *P. tremula*) growing on the mountains on the northern frontier of India (Darkot Pass, Bunji on road to Gilgit, etc.). *Pemphigus* sp. forms galls on the leaves of poplar trees (*P. euphratica*, etc.) in Baluchistan where it is exceedingly common. The young larvæ hatch out in the spring and collect in one place on the under-side of the leaf and suck out the sap. The irritation set up gives rise to an elongate swelling which takes various shapes, the convex part arising on the dorsal surface of the leaf. The larvæ live in the interior of the swelling and mature about mid-summer. The swelling by then has turned pink and yellow, dries slightly and opens on the under-surface, and the winged flies crawl out and escape.

Oregma bambusæ is a small black aphid which attacks the leaves of the bamboo *Bambusa arundinacea* in Dehra Dun. The insect is easily seen as it covers the leaves with a black sticky gum. Fig. 309 shows the apterous viviparous female and the winged female of this pest.



306. *Pemphigus edificator.* *a*, gall formed by the larvæ; *b*, winged fly.
307. *Pemphigus napæus.* *a*, young larva; *b*, mature fly.
308. *Pemphigus immunis.* *a*, young larva; *b*, *c*, lower and upper sides of galls made by these larvæ; *d*, mature fly.

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FAMILY XIII.—*Aleurodidæ*.

These are minute insects with mealy wings, seventeen-jointed antennæ and two-jointed feet terminated by two claws and a third process. Little is known about them at present in India.

In some cases they form scales upon plants, as in the case of the *Coccidæ* (*vide* below). An insect named *Aleurodes eugeniæ* has been reported as infesting *Eugenia jambolana* trees in Poona in this way. *

MONOMERA.

Tarsi consist of a single joint only.

FAMILY XIV.—*Coccidæ* (Scale Insects).

The form in which these insects are most usually known is that of a small scale or shell-like body closely adhering to leaves, fruits, or to the bark of trees, shrubs, etc. The scales thus formed are of the most varied shape so that no general description can be given of them. The scale may be defined as an accumulation of excreted matter, combined with the cast skin or skins of the insect, covering the body either totally or partially, and thus acting as a shield under which the subsequent development takes place. All coccids do not form scales, but the habit of excreting a large quantity of matter to the outside of the body is universal. The insects are usually minute with but a single claw to the foot. The male has one pair of wings, but no mouth parts; the female is wingless and usually so degraded in form that most of the external organs and appendages cannot be distinguished. When first hatched they are tiny little creatures, and it is only later on that the females lose the powers of locomotion, although in certain forms the females do not lose their antennæ and legs. They have no distinction between head and thorax. The beak is three-jointed. It is as they approach the adult stage that they become stationary and their bodies swell up and legs diminish, and the excretions forming the scales are produced. The eggs are generally laid under the body of the female, and as she lays them her body gets thinner and dries up, forming a kind of dish-cover over

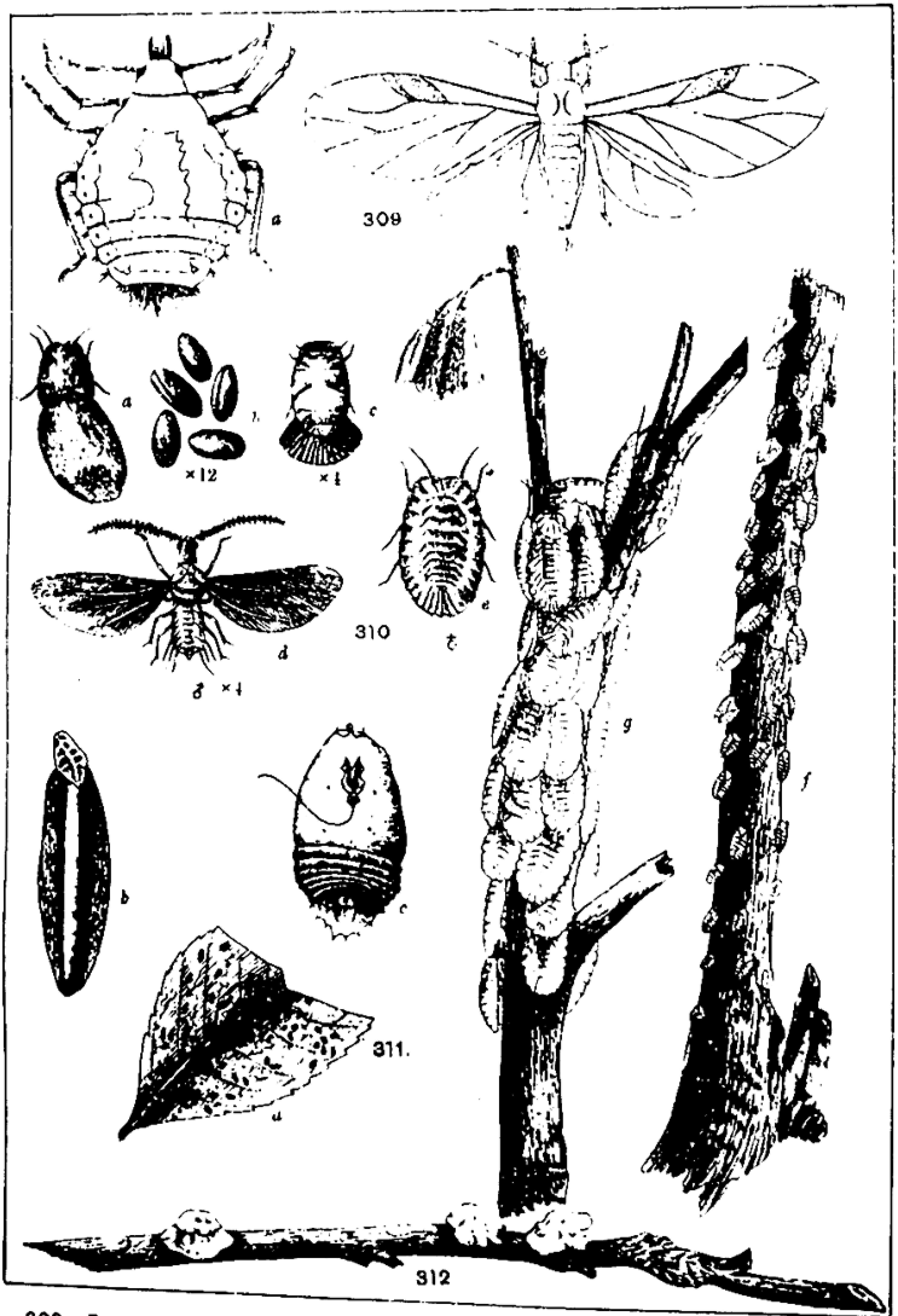
* For a fuller account *vide* Departmental Notes on Insects which affect Forestry, No. 1, p. 132

them, above which are the cast skins of the moults, and above these the encrustations of the scale. When the male larvæ change, they change to a pupal stage which is exceptional amongst *Hemiptera*. In spite of the female being wingless these insects spread more and cause more damage than any other family of insects. The ability to spread depends upon the activity of the larvæ and on the facilities which exist for the transport of the eggs. Many of these, which are often laid inside cottony masses, are blown about by the wind, others are transported by birds, etc. Cocoanut palms in the Laccadive Islands, areca palms on the Bombay coast, the sal tree in Northern India, and coffee bushes in Southern India and Ceylon are known to suffer to a serious extent from the attacks of the *Coccidæ*, whilst mango and orange trees, tea bushes, and other plants have been reported as harbouring various species.

Information as to the attacks of coccids in the forests is at present very defective in India. A genus bearing the name *Monophlebus* has within the last few years come to the front as containing serious forest pests. The members of the genus apparently confine themselves entirely to trees and woody shrubs. The life-history of one of the species, named recently by Mr. E. Ernest Green as *Monophlebus Stebbingi*, has been to some extent worked out, and the observations noted have shown that this class of scale has serious destructive capabilities when it swarms in large numbers. This insect lives on the sál tree, and during the last few years it has swarmed in ever-increasing numbers in the Siwalik sál forest and adjacent areas both to the west of the Jumna and east of the Ganges. Its like-history as far as at present known is as follows :—

Life-history of the sal tree scale insect, Monophlebus Stebbingi.

The young female larva first appears upon the sál leaves during November as a minute yellow speck. This increases in size, and during February it quits the leaves and takes up its position on the twigs. By the end of March it has grown into a fat, robust scale, half an inch or even as much as $\frac{3}{4}$ inches in length, by $\frac{1}{4}$ or $\frac{1}{3}$ in breadth, and covered with a white powdery substance, the colour beneath being orange or brown. The accompanying plate shows these insects feeding upon a sal sapling. The female is sexually mature about the beginning of April. During the whole of this period it retains possession of its legs and antennæ and walks about over the largest trees, but spends most of its time with its beak firmly embedded in the bark of the twigs and smaller branches, from which it sucks up the sap. It is also to be found in numbers on the upper portions of saplings. The scales are sometimes so thick on the stems and branches as to entirely cover the twigs, which appear as if encrusted with snow. During the whole of this period they exude enormous quantities of a saccharine solution, which coats the leaves and twigs closing up the stomata, and drops down on to the parts of the tree below, thoroughly



309. Bamboo Aphis (*Oregma bambusæ*). *a*, Wingless viviparous female; *b*, winged female.

310. The Sál tree white scale (*Monophlebus Stebbingsi*). *a*, female insect showing cottony sac containing eggs; *b*, eggs; *c*, male pupa case; *d*, male insect; *e*, wingless female scale; *f*, sál branch with cast larval skins attached to it by the sugary secretion; *g*, sál branch with mature female scales clustered on it.

311. *Fiorinia theæ*. *a*, leaf with insects *in situ*; *b*, scale of adult; *c*, adult female (ventral view). *b* and *c* enlarged.

312. Scales of *Ceroplastes ceriferus* (White Insect Wax).

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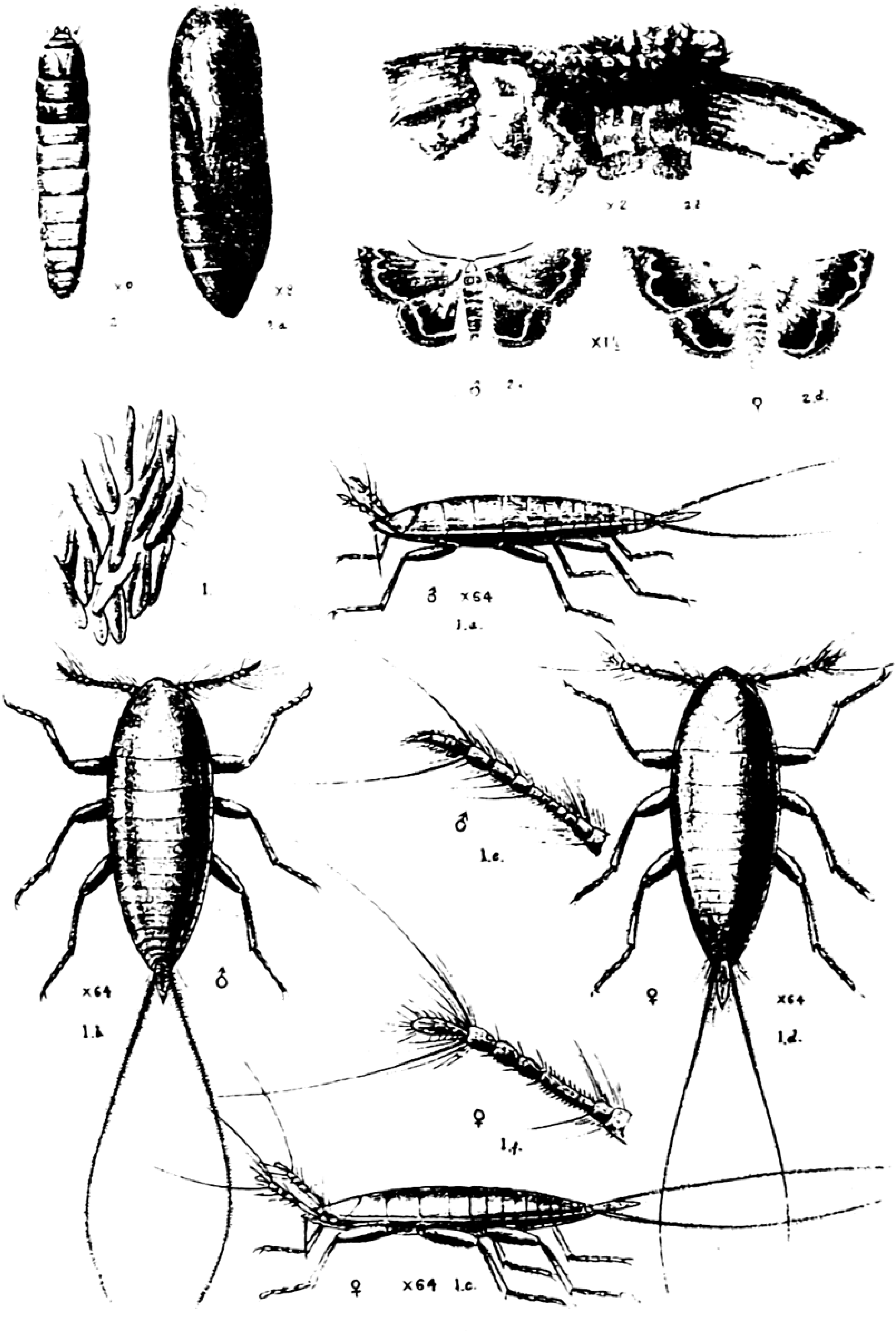


313. 1. The Lad insect *(Tacharasa lacca)*. 1. Egg skins magnified ; 1*a*, 1*b*, 1*c*, 1*d*, side and dorsal views of male and female insects ; 1*e*, 1*f*, antennæ of ♂ and ♀ enlarged. 2. *Eublemma amabilis*. 2, larva ; 2*a*, pupa ; 2*b*, cocoon ; 2*c*, 2*d*, male and female moths.

[to face page 165.

wetting them and the ground beneath. When the insects are numerous this excretion can be heard pattering down like rain-drops, and soaks everything. The male larva has not yet been found, but the male pupa is known and the male adult, which is a small red fly with a pair of black wings and some appendages at the end of its body, see fig. 310 d. It is ¼ inch in length with a wing expanse of ½ an inch. It appears in April and fertilises several females. Soon after pairing the male crawls down the tree seeking out crevices in the bark at the foot, or fallen trees, large stones, etc., as a sheltering place in which to lay her eggs. These are extruded from the body in a cottony sac-like bag which is partially covered after death by the scale-like skin of the female. The eggs are crimson in colour and shining, and one female lays over 450 of these in the sac. Fig. 310 a to g shows the female with the cottony eggs sac, the egg, male larval skin, male insects, female, a branch with empty female larval skins adhering to it and a branch with full grown female insects feeding on it.

The damage done by the pest is serious, as young twigs and smaller branches dry up under the many 'tappings' to which they are exposed, the crowns of the trees thus being thinned out; saplings similarly suffer severely. It has been already mentioned that this pest is seriously preyed upon by a coccinellid beetle *Vedalia guérinii*—*vide* p. 114. Other species and varieties of Monophlebus have been found upon sissu, teak, mango, *Casuarina equisetifolia* and *Prosopis spicigera*, but their life-histories have yet to be worked out.

Life-history of *Florinia theæ*. *Florinia theæ* is a minute scale insect which lives upon the leaves of the olive, Olea glandulifera, in the North-West Himalayas. It is a small, pale yellow, blunt, elliptical scale which comes to rest early in life and often thickly covers the leaves of the tree causing them to turn yellow and drop off. Fig. 311 shows this insect and a portion of a leaf infested with it. The insect also attacks the tea plant.

Lecanium nigrum is a minute black scale which has been reported as attacking the Ceara rubber, *Manihot Glaziovii*.

Dactylopius adonidum is a small scale which has been reported as infesting *Cedrela sp.*, *Artocarpus faxinifolius*, *Ficus mysorensis*, *glomerata*, *and asperrima* in Mysore.

Life-history of the *Lac insect*. Amongst useful species the lac insect, *Tachardia lacca*, which secretes both wax and dye, the lac being poured out by glands on the back, must be mentioned. It lives upon the dhak, ber, pipal, kusum, and other trees. The insect feeds upon the young twigs of the trees, sucking up their sap. As soon as the larvæ escape from the eggs they crawl about in search of sappy twigs. When satisfied they become fixed to them and remain

sucking up the sap by means of their proboscis with which they have pierced through the young bark. In this position they form a sort of cocoon or shell covering by excreting a resinous substance. The male cocoon is ovoid in shape, the female circular and larger. In about 2½ months the female and male insects mature. The female, however, remains *in situ* and throws up round herself a larger coating of resin. As the insects occupy positions on the twigs in close juxtaposition to one another, these coats join and this forms the lac of commerce. Fig. 313 and 314 show various stages of this insect with branches infested by the scale and the larva pupa and moth of one of its predaceous foes the insect *Enblemma amabilis.* There is a very large export of lac from India, and it is a valuable minor product of the Indian forest.

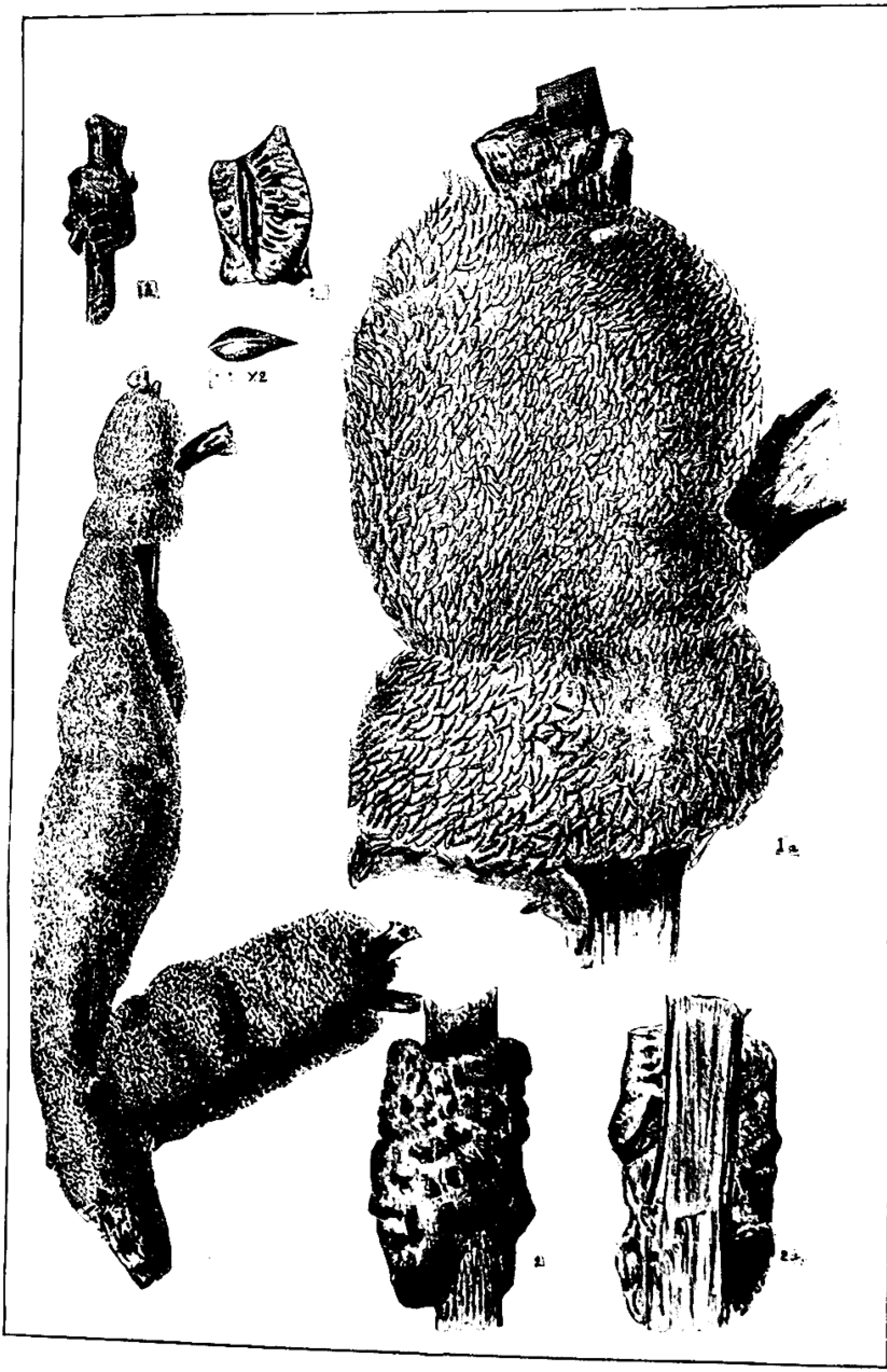
The cochineal insect, *Coccus Cacti*, was introduced into India in 1795 when it was placed upon the indigenous *Opuntia.* It thrives very well upon this and has a large commercial value owing to the valuable dye it produces.

Life-history of *Ceroplastes ceriferus.*

The insect known as White Insect Wax, *Ceroplastes ceriferus*, is an inhabitant of Central and Southern India. It secretes little conical masses of a sweet white waxy substance around it (fig. 312) and is to be found at times fairly numerous upon pipal and other trees. These white masses are sought for eagerly by jungle tribes, especially children, and eaten with relish. The young larvæ swarm on the trees from the wax masses in February and March in Chota Nagpur. They are tiny orange grubs and feed at first on the wax excretion. This wax was tried for candle purposes before the days of kerosine as it was hoped that it would be able to rival the Chinese form, but it was found to burn with a smoky flame.

USEFUL HEMIPTERA.

The family *Pentatomidæ* contains the soldier-bug, an insect which is useful in India, as it destroys caterpillars. The *Reduviidæ* are predaceous upon insects and probably destroy numbers of injurious forms. The Chinese insect wax (*Fulgoridæ*) was at one time a very valuable insect, as from it a large trade in wax candles sprang up, the world's markets being largely supplied from this source. It was thought at one time that the white insect wax (*Ceroplastes ceriferus*) of India would be utilisable for the same purpose, but its wax proved to burn with too smoky a flame, and the general



314 The Lac insect (*Tachardia lacca*) 1 Branch showing lac incrustation with swarming larvæ, 1*a*, same enlarged; 1*b*, transverse section of female cells to show their structure, 1*c*, longitudinal section of same; 1*d*, empty skin of female taken from cell. 2. Twig of lac showing holes made by the larva of ***Eublemma amabilis*** to enable the moth to issue from the interior of the lac incrustation where the larva pupates 2*a*, longitudinal section of a tunnel by which moth escapes.

introduction of kerosine caused the experiments being made with it to be given up. Its only use at present is as an article of food amongst the villagers. As already mentioned, there are two extremely useful insects in the family. The lac insect (*T. lacca*) secretes both a wax and a dye. The insect feeds upon the dhak (*Butea frondosa*), the ber (*Zizyphus jujuba*), pipal (*Ficus religiosa*) kusum (*Schleichera trijuga*), babul (*Acacia arabica*), and numerous other forest trees. It yields two crops in a year, the lac encrustings the twigs in large deposits, and forming a valuable article of forest produce, the world's supply being exported from India.

The cochineal (*Coccus cacti*) secretes a valuable dye. An inferior variety in India lives upon the Opuntia (prickly pear).

CHAPTER XI.

CLASS 5.—MYRIAPODA.

In this class the animals differ from insects in having the segments of the abdomen of similar size to those of the thorax, and they always carry some appendages. The legs are always more than 8 pairs in number.

The class is divided into two easily recognisable orders.

ORDER 1.—CHILOPODA (Centipedes).

Number of legs 15—20 pairs, only one pair on a segment; antennæ are composed of 14 or more joints; body flat. The animals may be useful as many are insectivorous. They are common in most parts of India and may be found crawling about during the daytime. Many live under the bark of trees or in rotting wood. The female produces a large number of young. In the large Assam species shown in fig. 315 a as many as 200 young ones were counted with the mother which was dug out, with the young ones coiled about her, from a large rotten *Bombax malabaricum* log in the Goalpara forests.

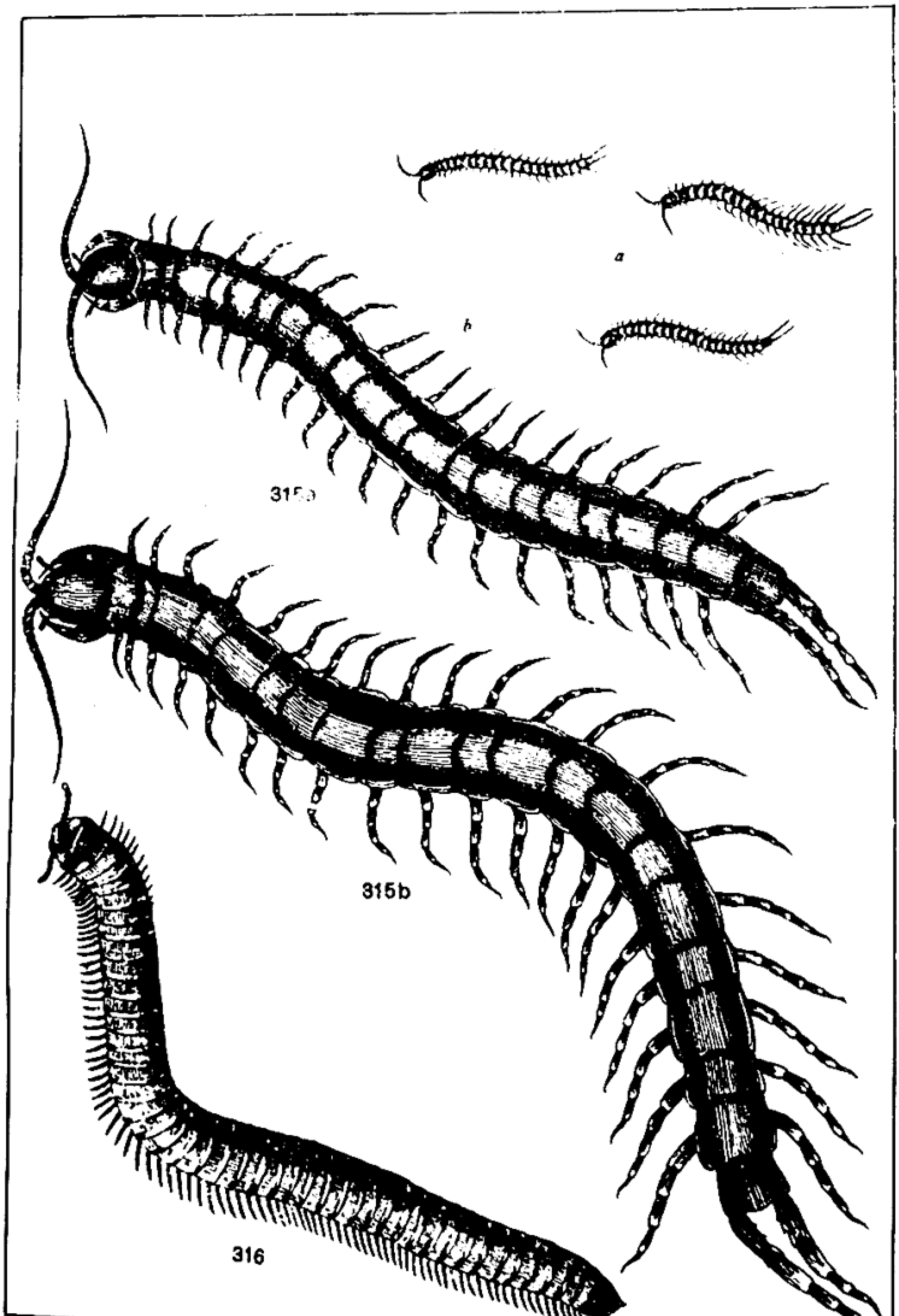
Fig. 315 b shows the large centipede, *Scolopendra,* common in the Dun.

ORDER 2.—CHILOGNATHA (Millipedes).

These are common animals resembling centipedes, but having an indefinite number of legs, most of the segments bearing 2 pairs; antennæ are composed of only 6 or 7 joints; body is rounded so as to be more or less cylindrical instead of flat as in centipedes.

These animals live on vegetable matter, chiefly decaying materials. They are to be commonly found in Indian forests engaged in this way.

Fig. 316 shows a common Indian Millipede.



315a. *Scolopendra* (?) *sp.* from Assam: (*a*), young; (*b*), mature female.
315b. Centipede from Dehra Dūn.
316. Indian Millipede.

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CHAPTER XII.

SYSTEMATIC EXAMINATION OF THE PHYLUM CHORDATA OR VERTEBRATA.

Chordata are characterised by having (1) a dorsal axial skeleton, which in a few of the lowest, and in the early embryonic stages of all, the higher vertebrata consists of a single soft rod, the notochord, but which in the majority of vertebrata acquires in the course of development the form of a firmly-jointed chain of bones (vertebræ) known as the vertebral column or backbone; a dorsal nerve-tube consisting of the brain and spinal chord, lying to the dorsal side of the axial skeleton on backbone, in which it is eventually enclosed; and also by the fact that the anterior part of the alimentary canal is modified for breathing, either gill-clefts and gills being present or lungs which arise in the embryo as paired outgrowths of the gullet. Most vertebrata have this structure, but it should be noted that there are several low marine members of the phylum in which some of these essentials are obscure, as, *e.g.*, in Balanoglossus and the Tunicates or Sea-squirts in which the skeleton is at best only represented in the larval stage by the notochord: the nervous system is feebly developed, as also are the sense organs. They are hermaphrodite and reproduction by budding also frequently occurs. Other small low vertebrates, of which Amphioxus forms an example, have the dorsal axial skeleton represented by a well-developed flexible notochord and the dorsal nerve-tube remains as a simple thick-walled tube, without a specialised brain; its central canal communicates with the exterior in front These low forms are, however, of no practical importance.

In the Vertebrata we are here considering the notochord is, with rare exceptions, an embryonic structure which is replaced by a chain of vertebræ, called the "backbone," and a skull and the dorsal nerve tube expands at one end to form a brain.

We will now consider the three vertebrate essentials in detail :—

(1) The skeleton consists of the dorsal axial skeleton and the appendicular skeleton. The dorsal axial skeleton consists

of the backbone and skull which have been already described in the Introduction. The appendicular skeleton consists of the bones of the shoulder girdle and fore-limb and the bones of the hip-girdle and hind-limb. These have already been considered (see pp. ix, x) in the Introduction.

(2) The Nervous System consists of the brain and sense organs and the spinal cord which have been already considered in the Introduction.

(3) Respiratory modifications of the anterior end of the alimentary canal may, as already explained, occur: *e.g.*, in fish we have gill-clefts and gills, whereas in mammals we have lungs.

The digestive, circulatory, excretory, reproductive system, etc., in the Vertebrata conform to the descriptions given in the Introduction.

CLASSIFICATION OF THE VERTEBRATA.

The Vertebrata are divided into two divisions depending upon the presence or absence of a notochord :—

(I) Vertebrata in which the notochord persists, the skull is a membranous and cartilaginous bag and no jaws or limbs are present. In other respects these Vertebrates resemble fishes. The Lampreys are a good example of this division, which is a small one. They attach themselves by suction to living fish which they devour. They do not occur in India and are unimportant.

(II) Vertebrata in which even if, as is very rarely the case, the notochord persists, there is present a backbone and skull, jaws, and usually (though not always) two pairs of limbs. This is a very large division including the rest of the Vertebrata, which are divided into (i) Fishes, (ii) Amphibia, (iii) Reptilia, (iv) Birds, and (v) Mammals. The Fish, Amphibias, and Reptiles are of secondary importance here and will be treated of shortly only, whereas the birds and mammals will be considered in greater detail.

CLASS I.—PISCES (Fish).

In fish the body is usually compressed and spindle-shaped : head, body, and tail pass gradually into each other, the last being very muscular ; there is no neck and the movement of the head is usually very limited. The body is covered with a somewhat thin epidermis which may contain cells whose secretion imparts to the skin its shining character. The dermis often contains ossifications, of which the best known are the so-called "scales," which are in bony plates lying in cavities of the dermis. The limbs of fish may be wholly wanting or one pair may be absent, but in no case is the number greater than in the ordinary vertebrate type—namely, two pairs. When developed however, the limbs of fish are very different from those of other Vertebrates, consisting of expansions of the integument furnished with bony or gristly supports or rays, and thus constituting what are called "fins." The pair of limbs which correspond to the arms of man and to the fore-limbs of other Vertebrates are termed "pectoral" fins. The hind-limbs in fish are known as the ventral fins and are not only often wanting altogether, but when present are less developed than the pectorals and less fixed in position. As the pectoral and ventral fins represent the fore- and hind-limbs, there are always two of each when they are present at all, and they are therefore spoken of as "paired" fins. In addition to these, or in the absence of them, there are what are called median fins present. These are similar in appearance to the others, but are unpaired, and they may be dorsal or ventral, and if near the vent, anal, and a broad fin at the extremity of the vetebral column, called the "caudal" fin or tail, which is placed vertically and is the chief organ of progression of a fish.* Respiration is aquatic and is effected generally by means of gills

* Prof. G. B. Howes, F.R.S., in his opening address as President of the Zoology Section at the meeting of the British Association at Belfast in 1902, objected to this terminology in the following words :—"To speak of the median fins as dorsal, caudal, and anal, of the pelvic as ventral, and of the pectoral in its varying degrees of forward translocation as abdominal or thoracic, though a convention of the past, is to-day inaccurate and absurd . . . . . I would propose for the future that the 'anal' fin be termed *ventral*, the ventral *pelvic ;* and that for the several positions of the pelvic, that immediately in front of the vent . . . . . . be termed *proctal*, the so-called 'abdominal' *pro-proctal*, the so-called 'thoracic' *jugular* (in that it denotes association with the area of the 'collar-bone'), and the so-called 'jugular' *mental*."

or branchiæ. The arrangement and structure of the gills varies considerably in the different orders; it will suffice here to say that the gills consist of a single or double series of flat cartilaginous leaflets covered by mucous membrane, richly supplied with blood and arranged on bony or cartilaginous arches. The branchial arches and branchiæ are suspended in cavities placed on either side of the neck, and ordinarily there is only one such cavity on each side. The water is taken in at the mouth and gets to the branchial chambers by means of a series of clefts or slits which perforate the pharynx. Having passed over the gills and lost its oxygen, the useless water makes its escape behind by an aperture, called the "gill-slit," which is placed on the side of the neck. The opening of the gill-slit is closed in front by a chain of flat bones which form the "gill-cover" and by a membrane which is supported upon a variable number of slender, bony spines. Whilst the respiration of fishes is truly aquatic, most are nevertheless furnished with an organ which apparently corresponds to the lungs of higher Vertebrates. This is known as the "air-bladder" and is a sac filled with gas and situated between the alimentary canal and the kidneys. In the majority of fishes this bladder simply acts as an adjustable float. The anus or vent may lie at the boundary of the trunk and tail, as in all higher Vertebrata, but has moved forwards, sometimes even far on to the trunk. The anal fin in such cases follows the anus and is usually found close behind it. Fish are what is termed cold-blooded animals, *i.e.*, their temperature is the same as that of the medium in which they live. Most fish are truly oviparous, and the ovaries are familiarly known as "roe." The male organs of reproduction are known as soft "roe." Some fish retain their eggs within the body till the young are hatched.

The fish are of no importance for the purpose of this work, and we shall not consider the various orders into which Pisces are divided. Fig. 317 shows the well-known Mahseer (*Barbus tor*) and fig. 318 *Clupea ilisha* the 'sable-fish' or 'hilsa' an excellent edible fish which swarms up all the larger rivers of India and Burma, generally as soon as the monsoon commences.

CLASS II.—AMPHIBIA.

This class of Vertebrata comprises the frogs, toads, and snake-like

Fig. 317

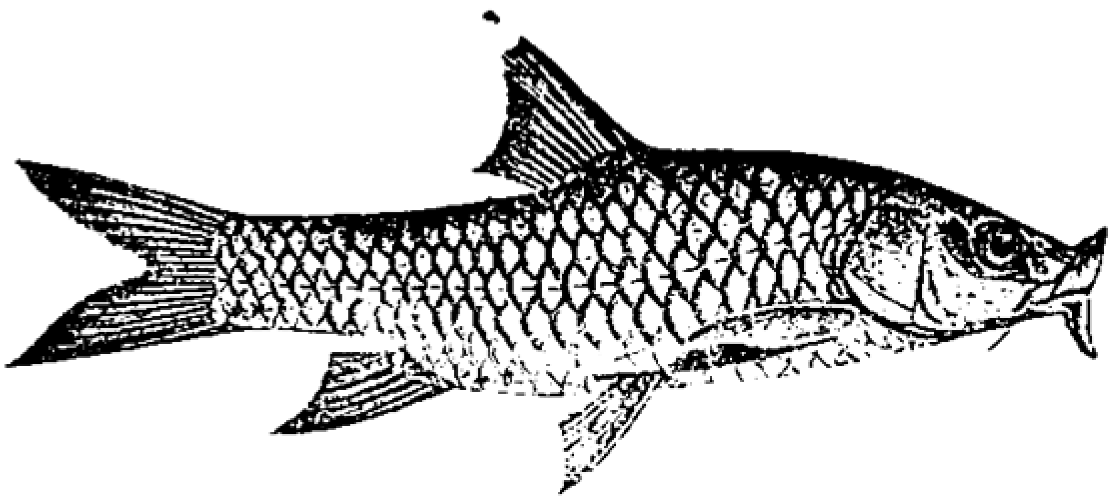
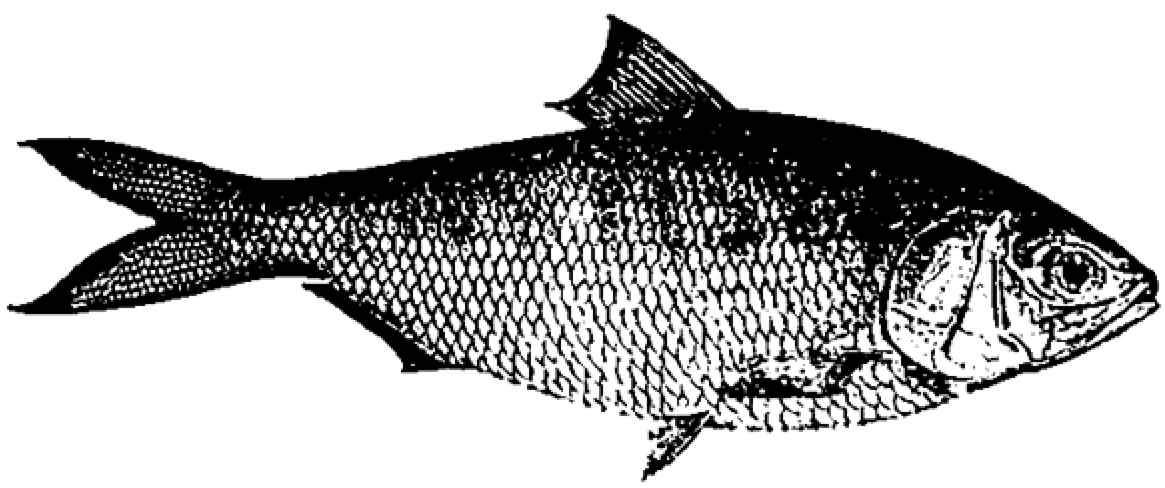


Fig. 318.



317. THE MAHSEER (*Barbus tor*).
318. THE HILSA (*Clupea ilisha*).

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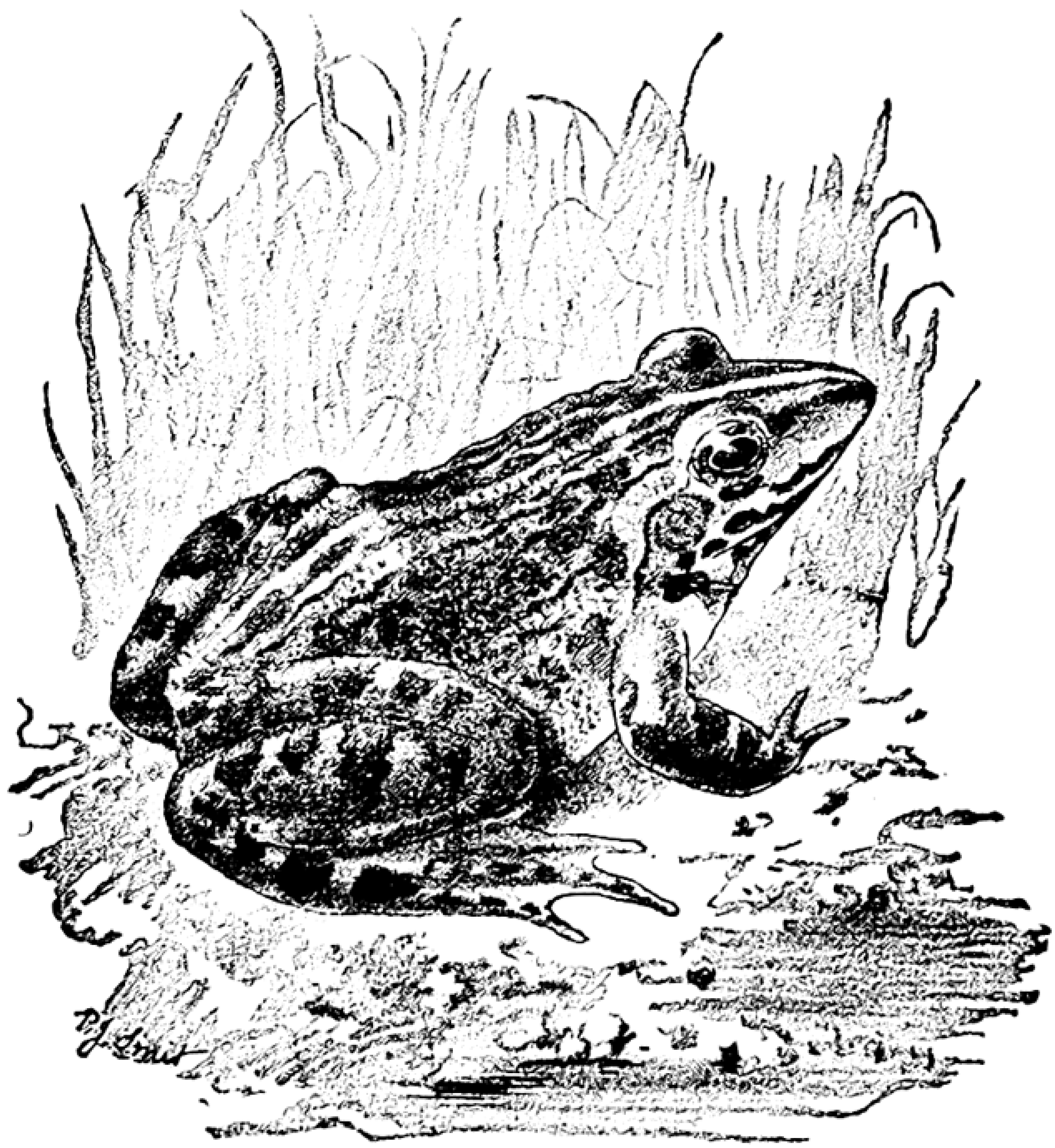
Fig. 319.



319. A Frog (*Rana tigrina*).

to face page 173.

Cœcilians. A few newts occur in India. One, *Tylototriton verrucosus*, first described from Yunnan, was obtained by the late Dr. Blanford and others in Sikkim. In all cases gills or branchiæ adapted for aquatic respiration are present during a part or the whole of life; but in all cases true lungs adapted for breathing air are ultimately developed, even when the gills are retained through life. All pass through some sort of metamorphosis after being set free from the egg. The imbs may be absent or there may be only one pair, but in no case are they ever converted into fins. When median fins are present, as is sometimes the case, they are not furnished with fin rays, etc., as in fish. The skull always articulates with, or is jointed to, the spinal column by two articular surfaces or condyles. There is a common cavity or "cloaca" which receives not only the termination of the intestine (rectum), but also the ducts of the kidneys and of the reproductive organs. The skin is soft and glandular, and, as a rule, neither horny nor bony structures are developed in it. In the great majority of cases the Amphibians commence life as water-breathing larvæ provided with gills; but in their adult state they possess two air-breathing lungs, the gills sometimes disappearing when the lungs are developed, but being sometimes retained. In most cases, and always if retained, the gills are external, placed on the sides of the neck, and not contained in a special cavity, thus differing from the gills of fishes. The frog (*Rana*) which belongs to the Order Anoura, is a good example of a typical Amphibian. The larval state is passed in the water and the animal is then furnished with a tail and has gills. The adult has no tail and breathes wholly by lungs, and through the skin. Both pairs of limbs are always developed in the full-grown animal, and the hind-limbs are enormously developed, being considerably longer than the fore-limbs and have the toes webbed, whilst those of the fore-limbs are free. The frog swims very powerfully, and can also take extensive leaps. The skin is soft. The spinal column is short; the dorsal vertebræ are very long, and the ribs are quite rudimentary. The bones of the fore-arm (radius and ulna) and those of the leg (tibia and fibula) are united to form single bones. The frogs are distinguished from some other members of the order by having a tongue which is fixed to the front of the mouth, and can be protruded at will, while the upper jaw is always armed with teeth. The

lungs are comparatively well developed, and as there are no ribs by which the cavity of the chest can be expanded, air is taken into the lungs by a process resembling swallowing. The skin also plays an important part in the æration of the blood and the frogs can carry on their respiration by means of the skin without the assistance of the lungs for a very lengthened period. This, however, does not give credence to the stories that frogs and toads have been found in closed cavities in solid rock, no authenticated instance of such an occurrence being known to science. The heart is divided by a septum into two auricles, right and left; the latter is the smaller and receives blood from the lungs, whilst the right receives the blood from the rest of the body. The ventricle is undivided. The ova of frogs are deposited in masses or strings in water and the young are familiar to all as tadpoles. Upon its escape from the egg, the young frog presents itself as a little fish-like creature with a broad head, a sac-like belly, and a long, compressed tail with which its swims actively. It breathes by means of gills of which there are two sets, one external and the other internal. At first there are no limbs; but as development proceeds, the limbs make their appearance – the hind-limbs first and then the fore-legs. The tail, however, is still retained as an instrument of progression. Ultimately when the limbs are fully developed, and the gills have given place to lungs, the tail is absorbed, and the animal now takes to the land as a perfect frog. From the above it will be seen that when hatched the tadpole has gills like a fish, but has lungs just as the typical fish has an air-bladder. Its metamorphosis is essentially a change from a fish to a land animal by the loss of the gills and the development of an air-bladder into functional lungs.

The Amphibia are cold-blooded and are of importance since they connect the fish with the reptiles and birds on the one hand and mammals on the other.

In India the chief Amphibia met with are the bull-frogs, little brown frogs, tree frogs, and toads. The frogs and toads of India are classed in six families containing 134 species. *Rana tigrina* (fig. 319) is a common Indian frog. Tree frogs, of which there are many Indian species, have the tips of their toes and fingers expanded to form disc-like suckers for climbing trees. Frogs feed on insects, probably destroying numbers of injurious species, and so are of use in this way.

Fig. 320.

320. INDIAN TOAD (*Bufo melanostictus*).

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Bufo melanostictus (fig. 320) is a common Indian toad. The Cæcilians are only found in India, the Malay countries and Archipelago, the Seychelle Islands, Tropical Africa, and Tropical America. Limbs are absent and tail absent or rudimentary; body is long and worm-like or snake-like. These Batrachians are found in damp situations, usually in soft mud. The eggs are very large and deposited in a burrow near water. The young do not leave the egg-mass until after the loss of the external gills; they then lead an aquatic life.

CLASS III.—REPTILIA.

The Reptiles include Crocodiles, Tortoises, Lizards, and Snakes. Both Reptiles and Birds have the following characters in common. There are never at any period of life gills or branchiæ adapted for aquatic respiration; the red corpuscles of the blood are nucleated; the skull articulates with the vertebral column by means of a single articulating surface or condyle (knuckle); each half of the lower jaw is composed of several pieces and is jointed to the skull, not directly, but by the intervention of a special bone, the so-called "quadrate bone" (fig. 321). In all Reptiles the blood is cold, *i.e.*, very little warmer than the temperature of the external medium in which they live. They are generally covered with scales and never with feathers. There is no division between the cavities of the thorax and abdomen, and the lungs are not connected with air-sacs placed in various parts of the body. The limbs may be wanting or rudimentary, but in no case are the fore-limbs constructed upon the type of the wing of birds, and in no living Reptiles is there a bone known as the "tarso-metatarsus."

With the exception of Tortoises and Turtles they are mostly of an elongate, cylindrical form, furnished behind with a long tail. The tortoise, lizard, and snake form typical examples of the Reptiles. The external covering of snakes and lizards consists of scales, whereas in the tortoise and also in the crocodile it consists of horny epidermal shields covering bony plates. Snakes have no limbs ordinarily and some lizards are also limbless; it should be noted, however, that some snakes have rudimentary hind-limbs. In the higher members of the class there are two pairs of limbs, which may be either adapted for walking or swimming. The internal skeleton is highly developed and always bony. In all reptilia the lower jaw, whether the separate

pieces are united together or not, is jointed to the skull by means of the "quadrate bone;" and as this often projects backwards, the opening of the mouth is often very extensive. Teeth are generally present, but they are chiefly used for holding the prey, and not in biting and chewing the food. The termination of the intestine (rectum) opens into the cavity called the "cloaca," which receives also the ducts of the urinary and generative organs.

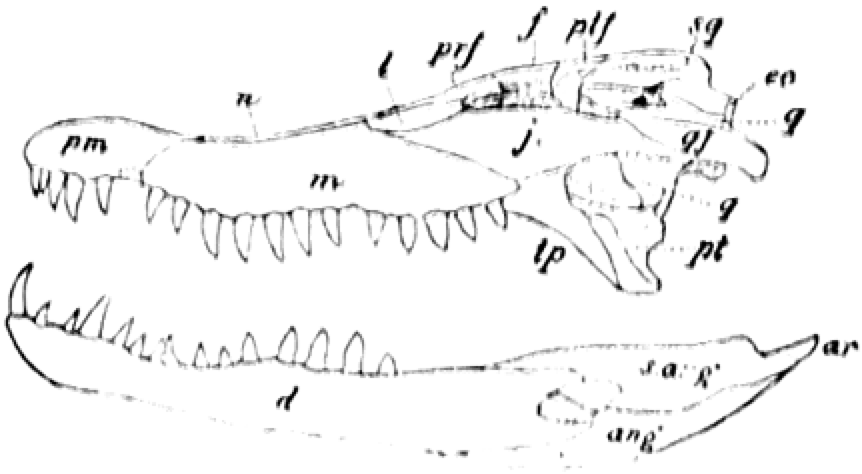
Reptiles generally lay eggs, but some snakes, such as the vipers and also a few lizards, are viviparous. The egg-shell is usually parchment-like, but in other cases contains more or less calcareous matter.

The class is well represented in fossil forms, several orders of extinct reptiles being known.

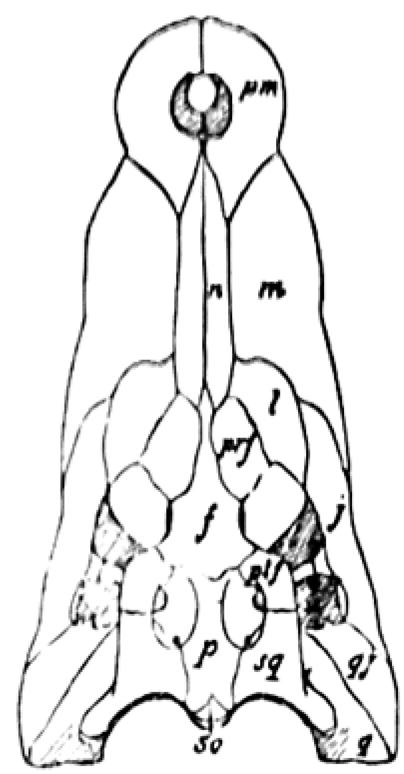
ORDER I.—CROCODILIA (Crocodiles).

Crocodiles differ from lizards and snakes (the two following orders) and resemble turtles and tortoises (1) in the position of the quadrate bone, which is wedged in among the bones of the skull, and (2) in the nature of the penis, which is single. They are distinguished from all other living reptiles by having the teeth planted in sockets, and (2) the heart consists of four quite distinct chambers (instead of three) the septum between the ventricles being complete. The halves of the jaw are united anteriorly as in the last order. The well-known form of the body of the crocodile is adapted for an aquatic life, the enormous tail acting as a propeller. The tail, in fact, is the principal organ of locomotion; the limbs being only called into use for clambering into and out of the water; the tail is also a powerful weapon of defence and attack. The limbs are short; in the fore-limbs there are five fingers, of which the fourth and fifth are small: the hind-limbs have four toes, which in some forms are webbed. The integument consists of bony plates formed by ossifications in the true skin, each bony plate being covered by a leathery shield of epidermis. In the Indian Crocodilia, the bony plates are developed only on the back; the covering elsewhere being leathery. The nostrils, which are large and valvular, the eyes and the external ear-openings are placed near the upper surface of the head, so that the animal can see and hear, as well as breathe, with its body immersed and hidden. The smallness of the cranium and the

Fig. 321.



A



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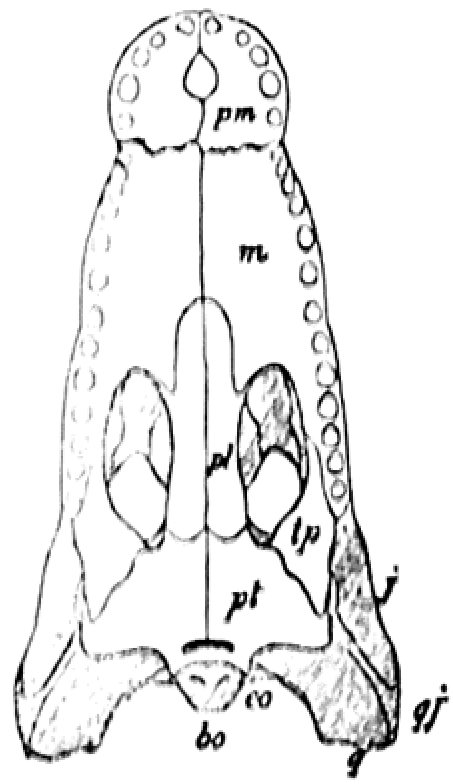

C

Fig. 322.

321. SKULL OF *Crocodilus palustris*. A, side view; B, upper view; C, lower view: *f*, frontal; *l*, lachrymal; *m*, maxillary; *n*, nasal; *p*, parietal; *pm*, premaxillary; *pt*, pterygoid; *q*, quadrate bone.

322 *Trionyx hurum* (young).

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huge size of the bones of the face and jaws, and the nasal passages opening near the tip of the snout, so as to enable the animal to breathe with its mouth below water, are characteristic of this order.

Crocodilus includes two Indian species, one of which, though inhabiting certain rivers, the Ganges, Brahmaputra, Indus, Mahanadi (Orissa), and Koladyne (Arakkan), with their tributaries, is very common in estuaries, and is sometimes seen off shore at sea. Fig. 321 shows the skull of this crocodile. *Gavialis* (the gharial), the other, is found in rivers, marshes, and ponds and is recognizable by its long, slender snout. It feeds entirely on fish.

ORDER II.—CHELONIA (Tortoises and Turtles).

There is no mistaking a tortoise. The shell over the back and the horn-covered, toothless jaws forming a kind of beak, separate them from all other four-footed creatures. Chelonia may be described as terrestrial or aquatic reptiles with walking limbs or with paddles. The marine paddle-limbed kinds are called Turtles, the others Land and Water-Tortoises. The body is enclosed in a bony case or box. This box is composed essentially of two pieces, one placed on the back and the other on the lower surface of the body, firmly united at their edges. The dorsal shield is more or less convex and rounded and is called the "carapace," whilst the ventral shield is more or less completely flat or concave, and is called the "plastron." Fig. 324 depicts the upper and lower surfaces of the shell of *Platysternum megacephalum*. They are united by their edges, but they have two openings, one in front for the head and fore-limbs, and one behind for the tail and hind-limbs. Both the carapace and plastron consist of bony plates covered by horny shields, and the form and arrangement of the superficial horny shields must not be confused with those of the underlying bony plates. All the aquatic forms have the body and limbs flattened, the limbs forming swimming paddles, in which the separate digits are not always distinguished externally. Some of the tortoises are exclusively terrestrial: in these forms the body is elevated into a dome-like carapace, and the limbs are club-shaped, with all the digits distinct. The head and fore and hind-limbs are retractile into the shell. Both eyes, furnished with eyelids, and ear-holes are present in the head. In the skeleton it will be seen

that the carapace is made up of (1) modified vertetræ, (2) modified ribs, (3) marginal bones developed in the skin, which complete the margin of the carapace and are ossifications of the true skin. The plastron is made up of bony plates, usually nine in number. The halves of the lower jaw are united anteriorly, and in the skull there are no nasal bones and no teeth. The quadrate bone is wedged in and hemmed in on nearly all sides by the neighbouring bones and stands nearly vertically, forming a broad articulating surface. The marine turtles, with the exception of the edible green turtle, are carnivorous as also are most of the fresh-water and semi aquatic tortoises: the land tortoises, such as *Testudo elegans* (fig. 323) are herbivorous. The Chelonia lay eggs which are either soft-shelled, as in the true trutle, or hard-shelled, as in the common mud-tortoise (*Trionyx hurum*, fig. 322) of the Gangetic delta.

ORDER III.—LACERTILIA (Lizards).

In many respects the lizards resemble the snakes, as they have the quadrate bones free instead of wedged in among the bones of the head, and they also have a double (paired) penis. In the case of the limbless lizard the resemblance is most marked. They can be distinguished by the following two characters:—

(1) The two halves of the lower jaw are always firmly united by a bony suture, whereas in snakes they are loosely connected by an elastic ligament and are widely separable.

(2) Hidden shoulder bones are always present in lizards, but are invariably absent in snakes. As a rule, too, lizards are distinguished by not having a row of enlarged ventral shields, but some snakes want these also.

Limbless lizards can be distinguished from snakes by the fact that they usually have either an external ear-opening or an exposed drum, neither of which are ever present in snakes, and also by the fact that the tongue in limbless lizards is not retractile into a basal sheath as in snakes. Further, lizards, with a few exceptions, have movable eyelids which are never present in snakes. Eyelids occur in snakes according to Boulenger, but are immovable. They are immovable in a few lizards (Scincus). The teeth are firmly fused with the bones that

Fig. 323.

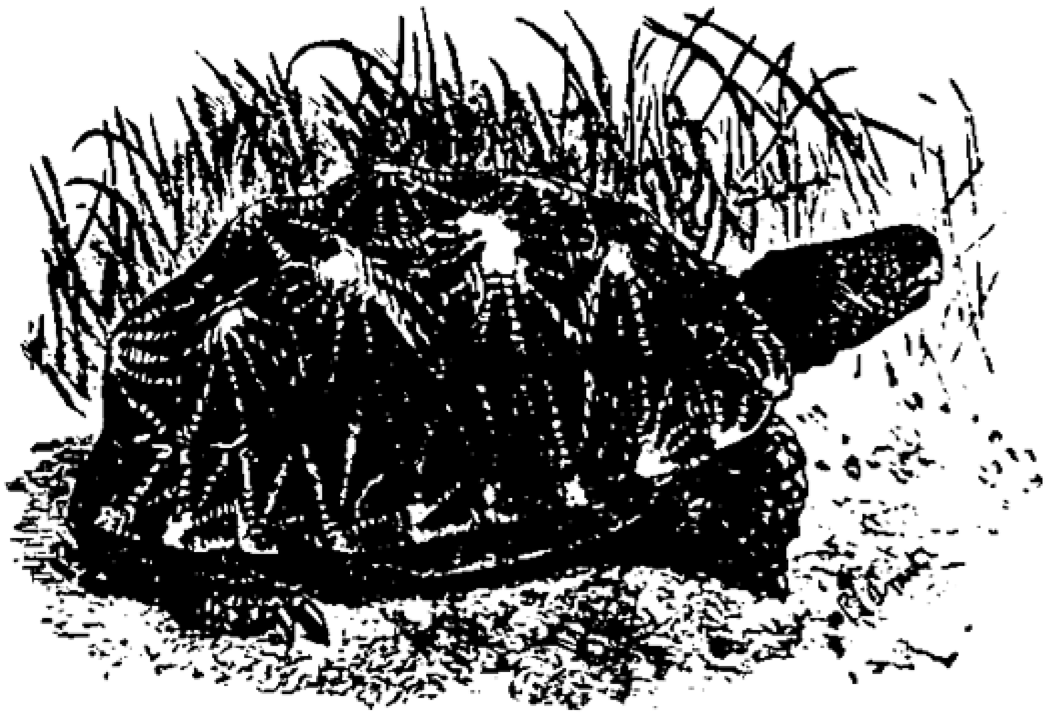
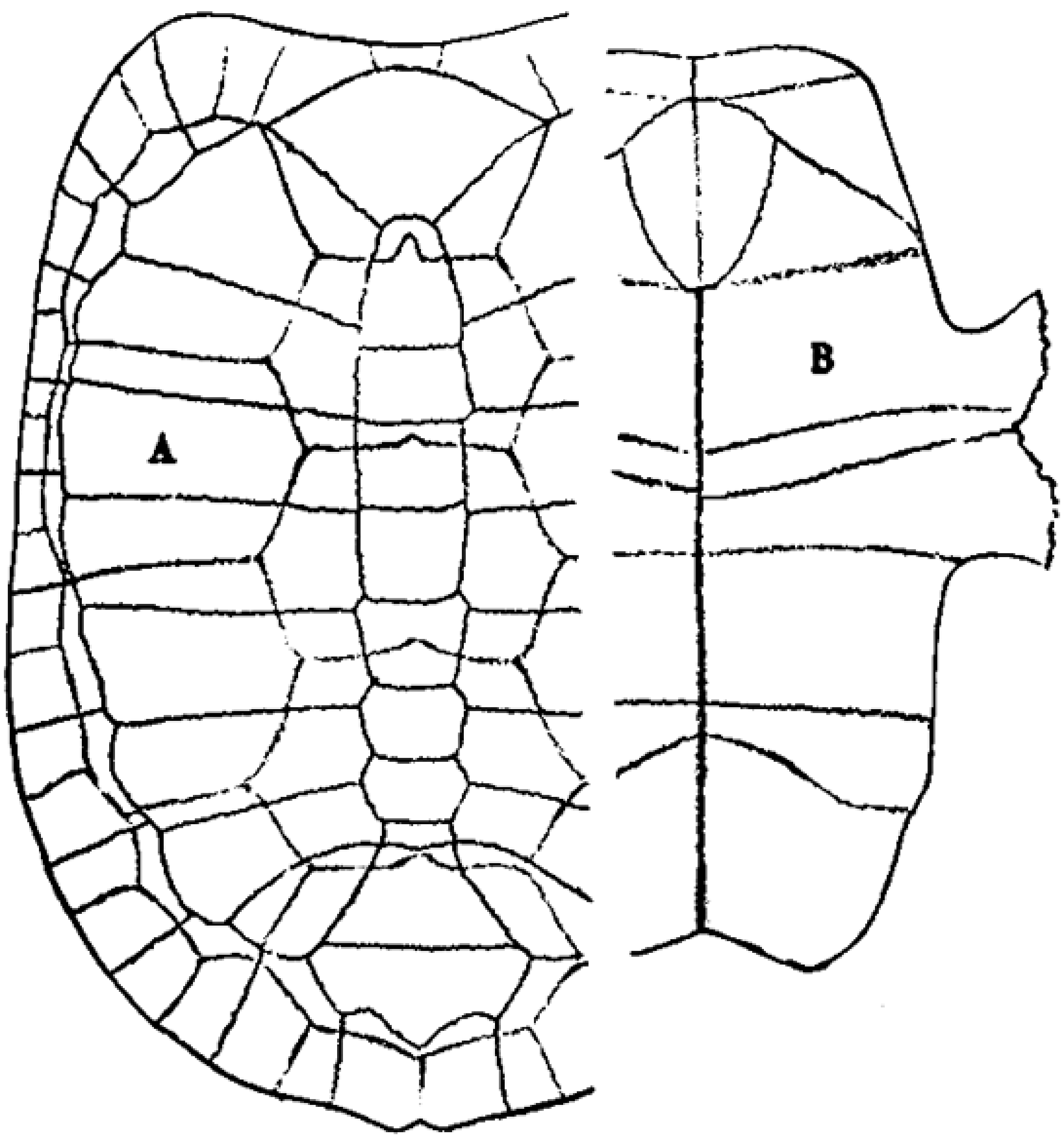


Fig. 324.



323. COMMON LAND TORTOISE (*Testudo elegans*).

324. DORSAL SHIELD (carapace) and ventral shield (plastron) of the shell of *Platysternum megacephalum*: A, carapace; B, plastron.

Fig. 326.

Fig. 325.

325. COMMON HOUSE GECKO (*Hemidactylus gleadovii*).

326. COMMON INDIAN LIZARD (*Calotes versicolor*).

To face page 179.

bear them and are not sunk in sockets. In the shoulder girdle we have a collar-bone in addition to the shoulder blade or coracoid. There are usually five toes to the foot (one Indian genus *Sitana* has four only) and in arboreal forms these and the tail are extremely long. The body is usually covered with scales.

In habits the lizards vary greatly. Almost all are more or less insectivorous or carnivorous, and hence for the most part are useful to man. Some lizards are noctural, but the majority are diurnal. *Varanus bengalensis*, of which the head is shown in fig. 327 A, lives in holes in dry places. *V. salvator* (fig. 327 B.), which has a peculiar snake-like tongue, is found in marshy localities or on trees over-hanging rivers; it enters the water readily. Others inhabit the banks of rivers and estuaries and even the sea-shore taking freely to the water, not only to escape enemies, but to seek their food, consisting of fishes and crustaceans. The great majority of lizards, however, live entirely on dry land, and of these some never leave the ground; others are arboreal such as *Calotes versicolor*, a common Indian lizard (fig. 326); others, such as some of the skinks' burrow into the ground; while others, as, for instance, some of the geckos frequent human inhabitations, and often have the scales of the under-surface of the fingers and toes specially modified to form adhesive discs for climbing up smooth perpendicular surfaces. *Hemidactylus gleadovii* (fig.325) is the commonest house-gecko of India. Although not much used by civilised man for food, lizards form a part of the food-supply of many savage and semi-civilised races.

ORDER IV.—OPHIDIA (Snakes).

As already stated, the snakes are closely related to the lizards, from which, however, they differ (1) in having the two halves of the lower jaw loosely united by ligaments and capable of separation; (2) in having no trace of a shoulder-girdle; (3) in having neither movable eyelids nor external ear-openings.

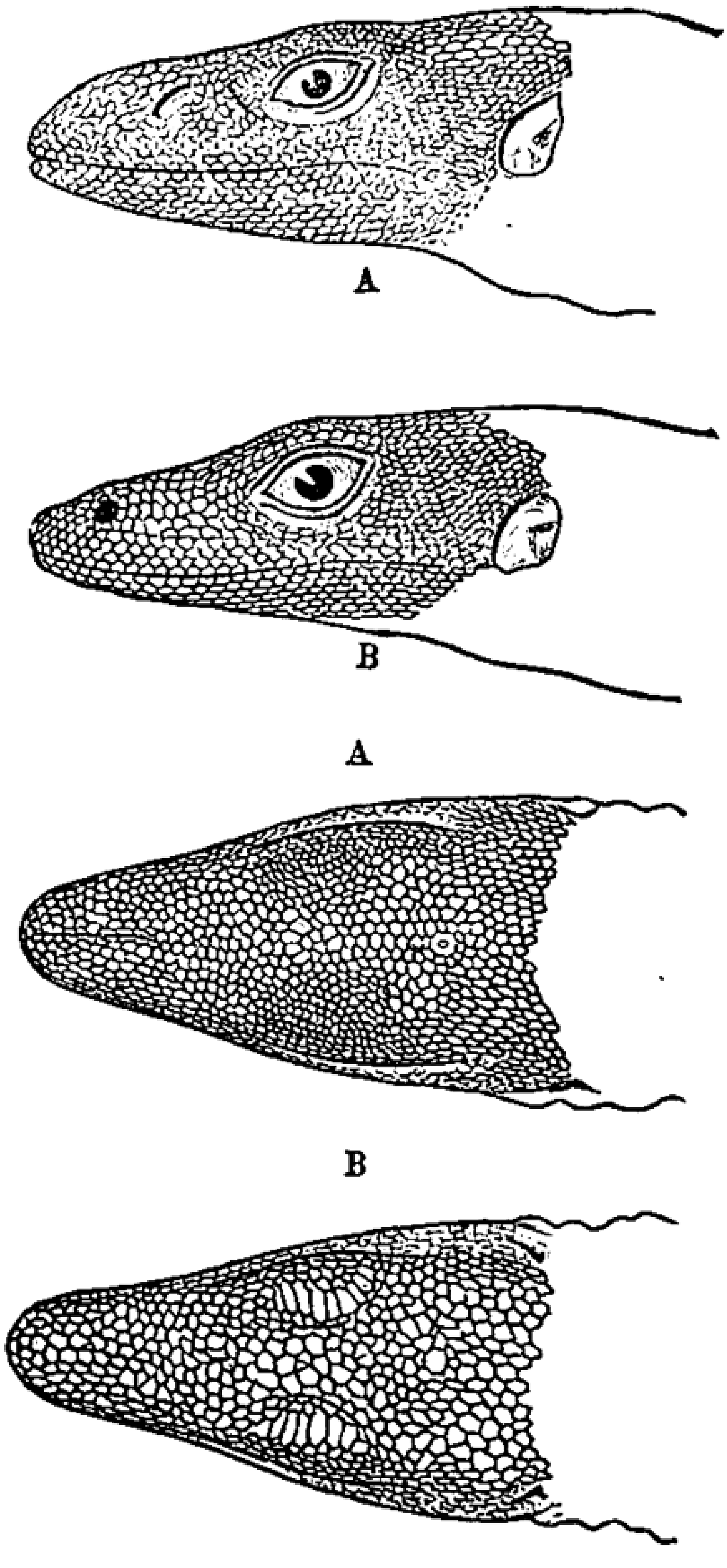
Not only have snakes no trace of a shoulder-girdle, no trace therefore of fore-limbs, but the great majority have also no traces of a pelvic girdle and hind-limbs. It is only rarely, as in the case of the Indian python, that rudiments of hind-limbs are present. In the absence of limbs, snakes crawl on the ends of their ribs. of which there

are a pair on nearly every vertebra, and which are not attached to any sternum. The skin develops horny scales, with which the body is covered, but never bony plates. In locomotion the great belly-scales are of great assistance by catching against roughnesses on the surface over which the snake is crawling, and thus affording a leverage. The looseness and mobility of the jaw-bones, the absence of limb bones, and the multiplicity of free ribs form the peculiarities of the skeleton of a typical snake. The teeth which, like those of other reptiles, are set backwards and are of use only for seizing and holding prey, and not for chewing, are numerous, and are found not only in the jaw-bones, but also on the bones of the palate. In the venomous snakes the front tooth of the upper jaw on each side is enlarged and deeply grooved or "perforated" along its whole extent, to convey the secretion of the poison-gland into the wound inflicted by the tooth. Certain snakes which are not poisonous, at least so far as man is concerned, have one more of the hindmost teeth in the upper jaw grooved. The venom-gland in the poisonous snake lies beneath the eye and is to be looked upon as a specially modified salivary gland. Its secretion (the venom) is a clear limpid, yellow-coloured, acid liquid, which owes its virulence to certain soluble albuminous bodies it contains. The poison, if dried at a moderate temperature, or if preserved in alcohol or glycerine, will retain its virulence unimpaired for years. A wide duct conveys the poisonous secretion from the gland to the base of the poison-fang. From its position among the muscles that work the lower jaw, the gland is squeezed when the snake forcibly contracts these muscles in biting, and the poison is thus ejected along the duct and the channelled tooth into the wound.

Owing to the extreme mobility of the bones of the jaws and palate, snakes are able to open the mouth not only in a vertical direction, but also in a horizontal one: the gape is thus capable of enormous distention, so that a snake can swallow prey of greater diameter than itself. The tongue is forked and retractile into a sheath at its base.

Snakes are all carnivorus and predaceous. The great majority live on the ground; but some live entirely underground, these often having the tip of the tail modified (*Uropeltidæ*). Others are almost exclusively arboreal, and have a long prehensile tail and a colour in which green predominates. A few are confined to fresh water; while

Fig. 327.



327. UPPER AND SIDE VIEWS OF A, *Varanus bengalensis*; B, *Varanus salvator*.

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a considerable number are exclusively marine. It is doubtful whether any snake is of direct benefit to man, while many are in the highest degree dangerous to him and his belongings. As regards the question of the determination of poisonous snakes, the only reliable way of deciding whether a snake is poisonous or not is to secure it and look at its teeth, to see whether or not the front pair in the upper jaw have the form of enlarged and grooved or perforated fangs.

There are nine families of snakes, all of which are represented in India; and it may be added that India is the only country in the world in which all the families are found, one being peculiar. It will be sufficient for our purpose to mention three here.

FAMILY I.—*Colubridæ.*

This is by far the largest family of snakes. One-third of the known Indian snakes are colubrids. It includes a large number of harmless species; a considerable number of species, which, though harmless to man, may be able to inflict a bite harmful to small birds and mammals; and numerous species, such as cobras, kraits, and sea-snakes, which are amongst the most deadly of all poisonous snakes.

The Colubridæ generally have the top of the head covered with large scales or head-shields, and the ventral shields also large (*cf.* fig. 328) except in the sea-snakes. They are divided into non-poisonous Colubridæ of which 140 Indian species are known, and poisonous Colubridæ, of which 39 Indian species are known.

The non-poisonous colubrids can be recognised by the large head shields on the top of the head, as shown in the head of *Tropidonotus piscator* (fig. 328) the loreal shields, and by the anterior teeth which are all solid, *i.e.*, not grooved. In Dipsas and Homolopsis and their allies, however, one or more of the posterior maxillary teeth are grooved. The anterior teeth are numerous and not very unequal in size, and are arranged (1) in a close-set row on each side of the lower jaw; (2) in a close-set row on each side of the upper jaw; and (3) in two close-set rows down the palate. Consequently the impression eft by the upper jaw in the case of a vigorous bite from a harmless colubrine might consist of four long parallel rows of punctures of

nearly equal size. They may be ground snakes, such as the common, large dhaman or rat-snake and the snake *Tropidonotus stolatus* (fig. 330); or arboreal, such as *Dryophis mycterigans*, a gentle snake often found in bushes (fig. 331) or live in fresh water.

The poisonous colubrines have the large head shields but no loreal shields. They can be at once detected by the arrangement of the teeth. As in the harmless (to man) snakes, there are (1) a row of close-set teeth along either side of the lower jaw; and (2) two rows of close-set teeth down the middle of the palate The form and arrangement of the upper or "maxillary" teeth is different; these are in a short row—only at most three or four in number—on either side, and the front tooth in each row is distant from the others and is usually enormously enlarged. This large tooth is the deeply-grooved or perforated poison fang above described. The impression left by the upper jaw, then, in the case of a vigorous bite from a typical poisonous colubrine snake would consist of two large punctures made by the poison fangs, while far behind each of these large punctures might be either a second small puncture, or a short row of, at most, three small punctures, made by the other maxillary teeth, and between these might be two longer rows of small punctures made by the palate teeth. The most deadly of the land poisonous colubrines are the Kraits (*Bungarus*, and the Cobras (*Naia*). The Cobra or Naga (*Naia tripudians*) shown in fig. 332, is the best known of the deadly snakes in India. The poisonous sea-snakes of the family are all very deadly. About 30 species occur in Indian seas.

FAMILY II.—*Viperidæ* (Vipers).

The Vipers are all poisonous, and the Indian species known as the Russel's Viper is one of the most deadly of all snakes.

Vipers can generally be recognised (1) by the shape of the head, which is something like the ace of spades, being almost triangular and very sharply constricted from the neck; (2) by the short blunt tail; and (3) by the fact that the head is usually covered, not with large shields, but with small scales like those on the upper surface of the body and tail; fig. 335 shows the head of *Trimeresurus monticola*.

A few tree vipers have, however, longish tails, and a few others have head shields like those of the colubrines. Vipers can, however,

Fig. 330.

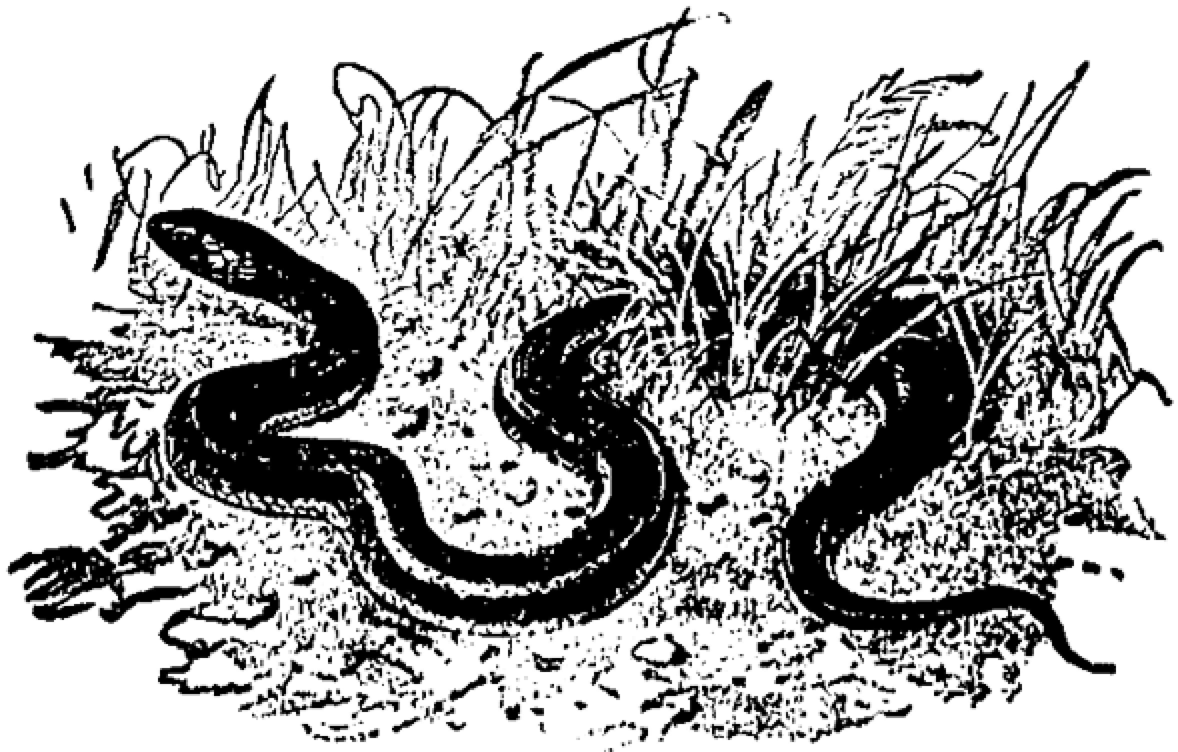


Fig. 331.

330. TROPIDONOTUS STOLATUS.
331 DRYOPHIS MYCTERIZANS

Fig. 334.

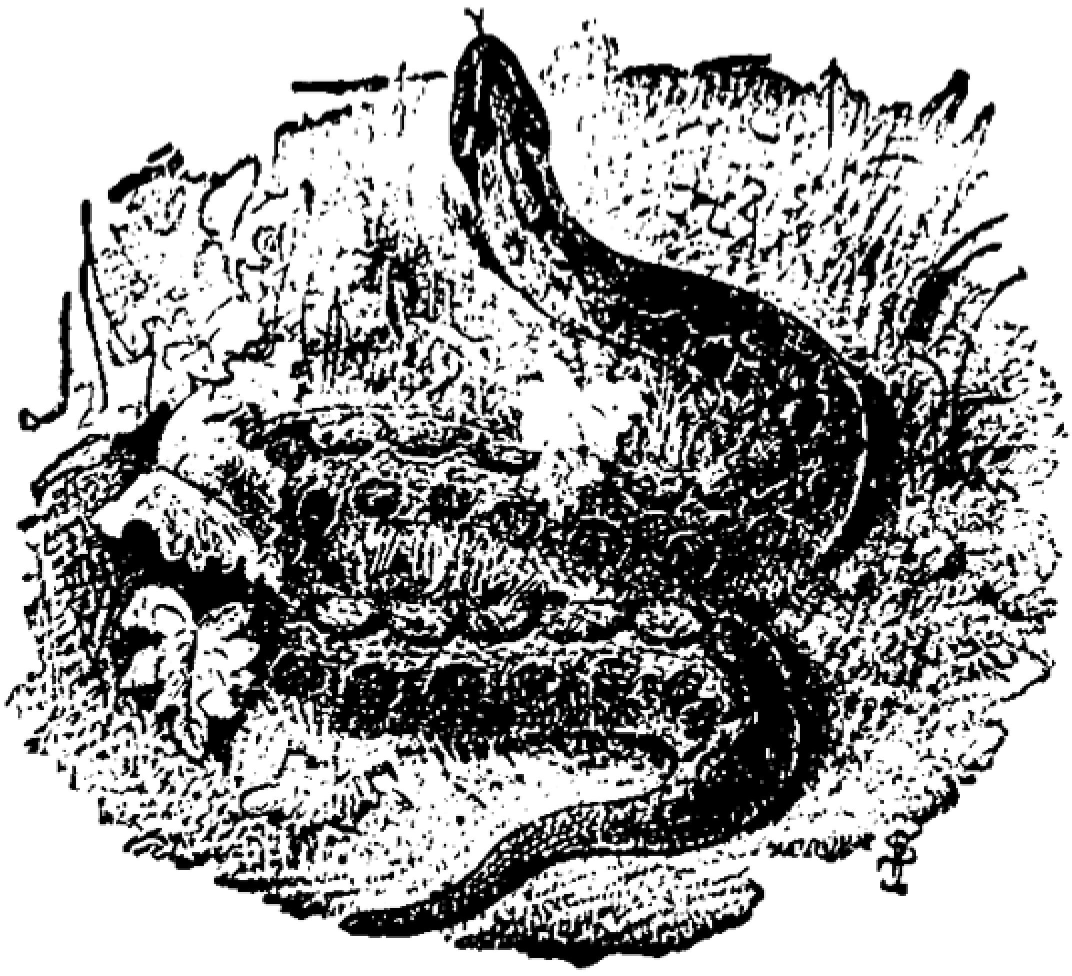
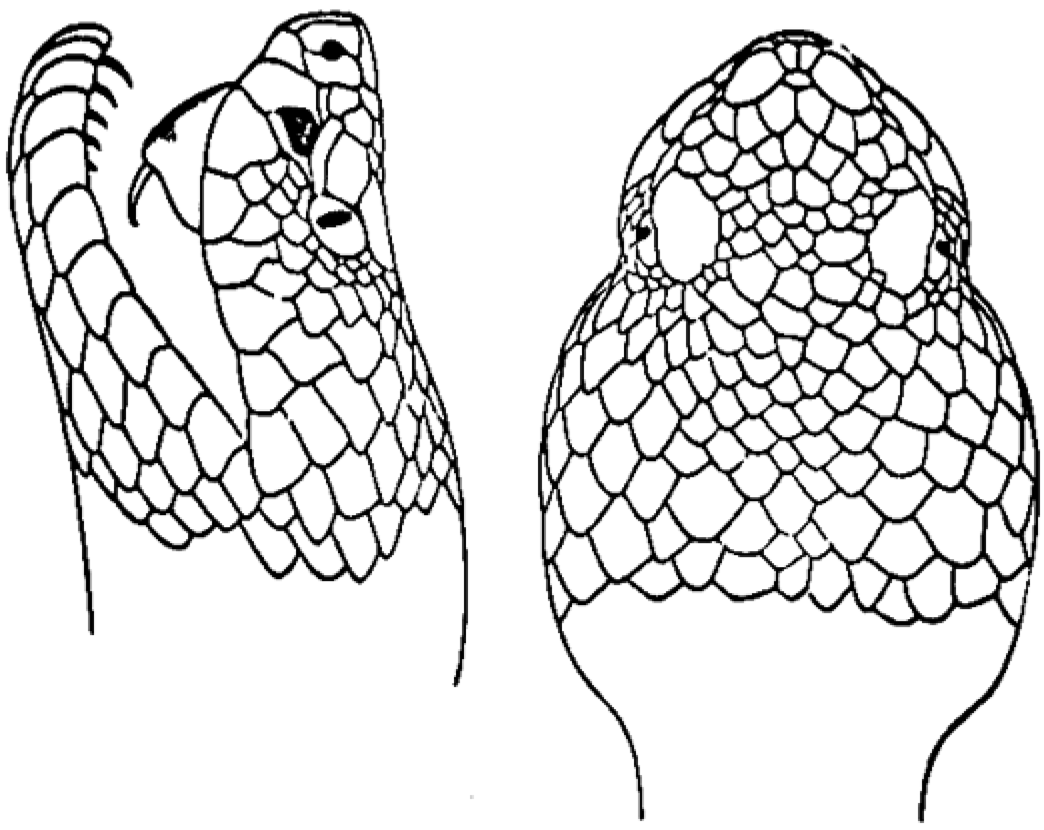


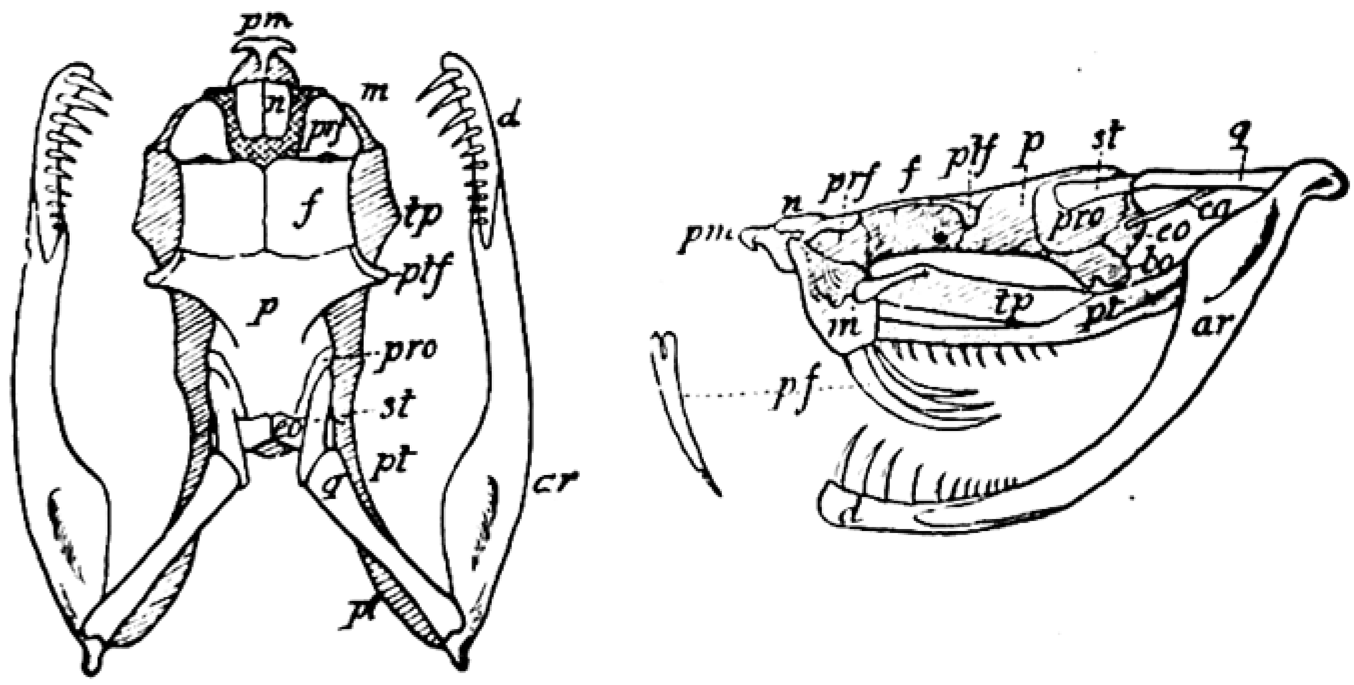
Fig. 336.



334. RUSSELL'S VIPER*(*Vipera russellii*).
336. HEAD OF *Trimeresurus monticola*.

Fig. 332.

Fig. 333.



332. THE COBRA (*Naja Tripudians*).

333. SKULL OF *Trimeresurus gramineus*. A, upper; B, side view: *m*, maxillary; *n*, nasal; *p*, parietal; *pf*, poison fang; *pm*, premaxillary; *q*, quadrate bone.

Fig. 328.

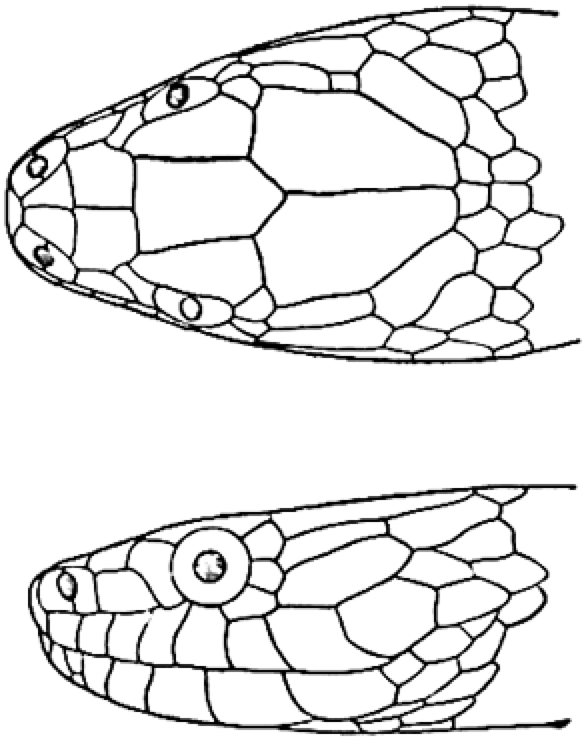
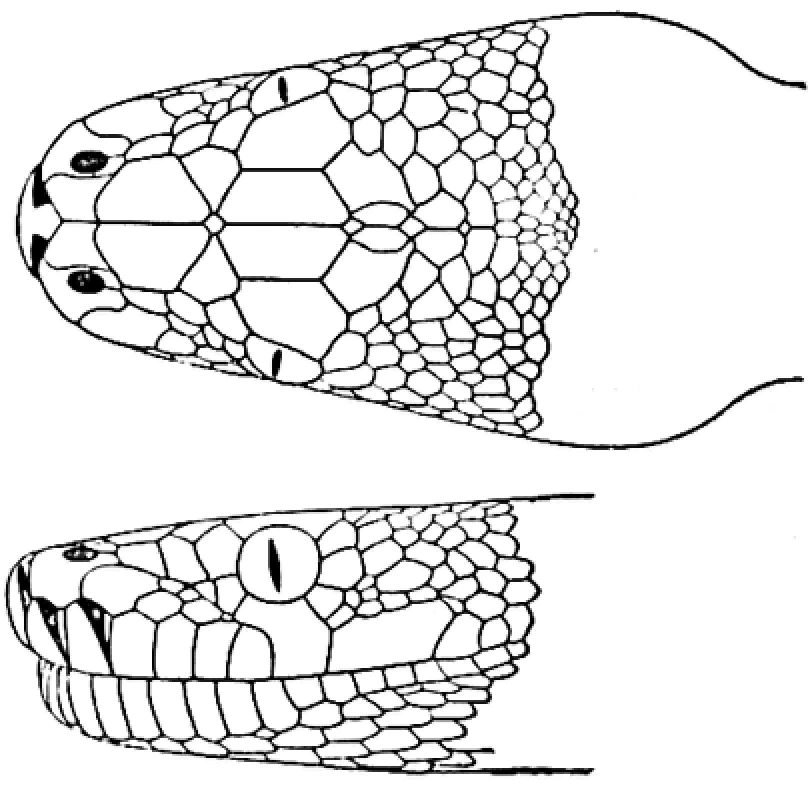


Fig. 329.



328. HEAD OF *Tropiaonotus piscator*.
329. HEAD OF PYTHON (*Python molurus*).

be always recognised by the form of the maxillary bone which is very short, can be erected vertically, and carries only one poison fang as in *Trimeresurus gramineus* (fig. 333). At the base of the poison fang there are indeed several reserve fangs to replace the functional fangs when broken or lost, but behind it there are no solid teeth as there are in most of the poisonous colubrines.

Vipers are viviparous and bring forth young alive. One of the deadliest of the Vipers is Russell's Viper, *Vipera russellii*, shown in fig. 334.

FAMILY III.—*Boiidæ* (Rock-Snakes, or Pythons).

This family includes the gigantic rock-snakes, or pythons, the Indian species of which are among the largest of all Ophidia. Fig. 329 shows the head of *Python molurus*. Pythons have not only a rudimentary hip-girdle, but also on each side a rudimentary femur, to which is attached a claw, which is externally visible beside the vent. They grow to as much as 23 feet in length in the hot moist semi-tropical portions of India, about half this length only being attained in the hot dry parts of the country. Pythons are fond of climbing trees. They feed on birds and mammals, which they seize with their teeth and then suffocate by squeezing them in their coils.

The female python hatches her eggs by coiling herself around them.

Fig. 336.

Fig. 337.

336. Head of the Jungle-crow (*Corvus macrorhynchus*).
337. The Red-billed Blue Magpie (*Urocissa occipitalis*).

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Chapter XIII.

Class IV.—Aves (Birds).

Birds are closely related to the Reptiles, with which they agree in having oval nucleated blood-corpuscles and a cloaca terminating the alimentary canal, into which the ducts of the genital organs also open; they also lay eggs; the skull articulates with the vertebral column by one knuckle or condyle, and each half of the lower jaw is composed of several pieces and is joined to the skull by means of the quadrate bone. Birds differ, however, obviously from Reptiles in their warm blood, and in the fact that they are covered with feathers. The form of the body is uniform, though the proportions of the head, neck and limbs vary somewhat. The trunk is short, plump, and nearly inflexible, a large part of its bulk being made up by the large muscles which move the wings and are attached to the sternum or breast-bone (f. 337). The head is prolonged in front into the beak, which varies much in form and length, and usually has the nostrils situated at the base, though they may be placed more forwardly as in geese and gulls (f. 336). The head is set on the neck at an angle, and the latter is very long and flexible, enabling the bird to reach any part of its body with its bill. The bill varies greatly; the upper portion may be curved down to form the hook in parrots, birds of prey, etc., or the lower one projected out as in the Scissor-billed tern, or the tips of the bill may be crossed as in the crossbills among the finches. The tail is very short and movable only at the base. It may have long feathers to it. The fore-limbs have been modified to serve as supports for the flight feathers. The shoulder girdle consists of shoulder blades, coracoids and collar-bones, the latter united into an arch called the *furcula* or "merry-thought." The digits are not visible externally except the thumb, and in flying birds the space behind the wrist and the shoulder is occupied by a triangular membrane and the whole limb in repose is folded up into a Z-shape, with the hand pointing backwards. The hind limbs support the body; as a rule the thigh is included in the trunk, though it is free in birds of prey. Following this is the chief bone of the leg, the tibia, with a small fibula attached to it. The foot usually forms a long shank and

is composed of the tarsus and metatarsus of other vertebrates, called the tarso-metatarsus, which is rarely applied to the ground, birds resting and moving on the toes only, which never exceed four in number, the first of which is generally directed backwards (fig. 338), and is often small or wanting. The fourth (outer front) toe may also be turned backwards, constituting the paired-tced feet in Parrots, Woodpeckers, etc. The skin in birds only contains one gland, the large oil-gland, at the root of the tail, the buttery secretion of which is used in lubricating the plumage. The skin is covered more or less completely with feathers which do not, however, usually grow uniformly from its whole surface, but from certain definite areas, and this may be seen in the young of birds whose young do not possess nestling-down. The form of these feather-tracts is of some importance in the classification of birds. The feet are usually covered with scales, either many small ones or comparatively few large ones, as in most birds. The ends of the toes are provided with horny claws; and spurs, consisting of a horny sheath over a cone of bone, occur on the shanks of some game-birds and on the wings in a few other forms, in both cases being used as weapons. Feathers, like claws and spurs, are products of the epidermis. A typical feather consists of a horny, cylindrical tube, the quill, the continuation of which is filled with pith and is grooved, and is called the shaft. The shafts bear the webs which form the lateral expansion of the feather. From their non-conducting nature the feathers serve to maintain the high temperature of the body.

In a skeleton of a bird the following points should be noticed as compared with the skeleton of a reptile:—(1) the large relative size of the brain-case in the skull which is set on the neck at an angle; (2) great size and width of the sternum which bears ribs on its sides only; (3) modification of hand in which the first three fingers only are present. In the case of flying birds the skeleton shows (1) the presence of a great keel in the sternum, serving as an attachment for the powerful muscles which move the wing and furnish the "breast"; (2) the fusion of the last few vertebræ of the tail into a vertically compressed plate; (3) the fusion of the collar-bones to form the "merry-thought" (*furcula*); (4) the absence of teeth in the beak; and (5) the hardness and lightness of a bird's bones.

The digestive system in birds consists of the beak, tongue, gullet,

Fig. 338.

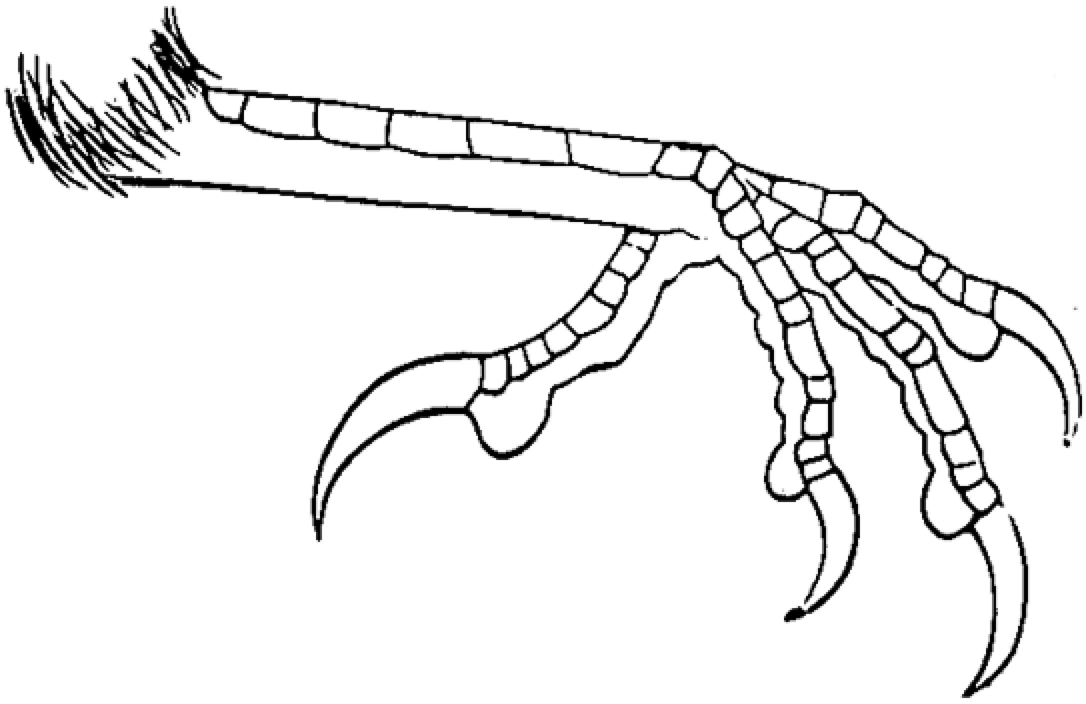
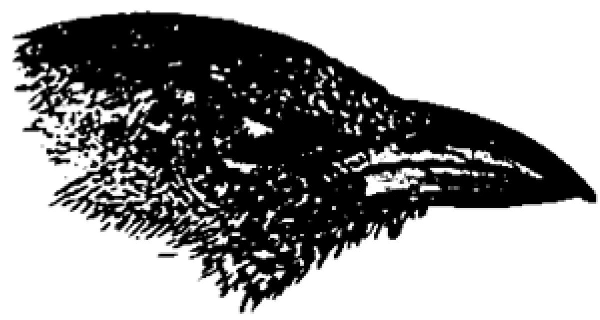


Fig. 339.



338. FOOT OF THE JUNGLE-CROW.
339. HEAD OF *Crateropus canorus* (the Jungle Babbler).

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Fig. 340.

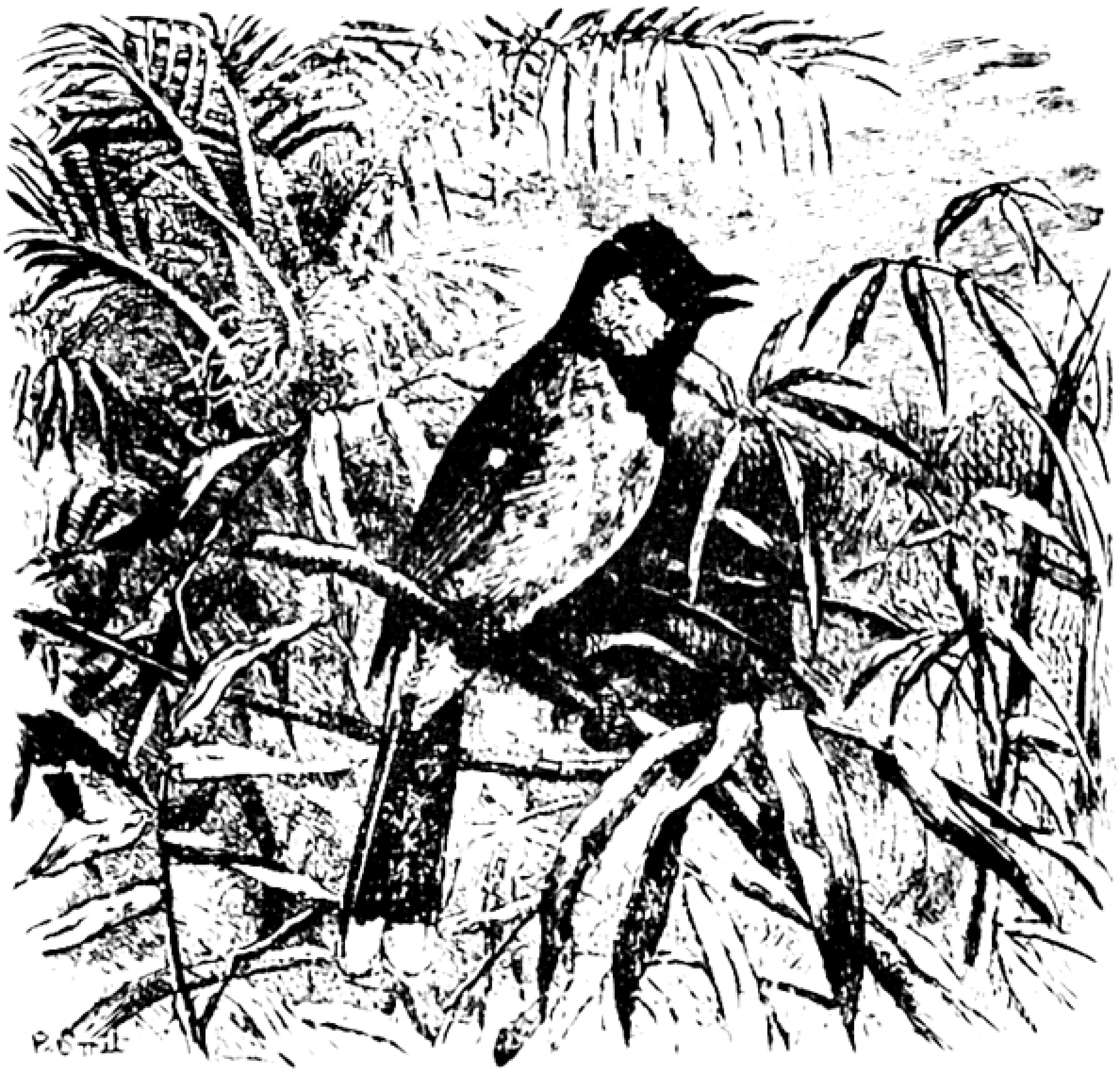
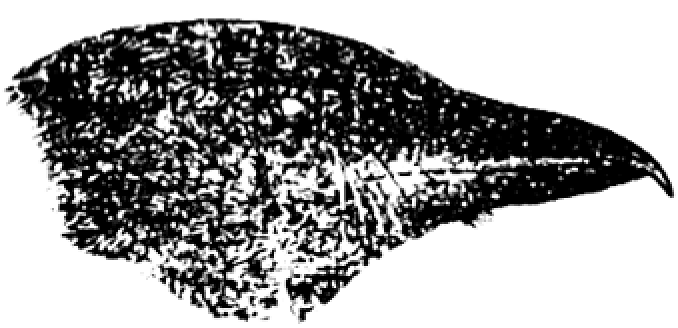


Fig. 341.



340. THE WHITE-EARED BULBUL (*Molpastes leucotis*).
341. THE BLACK DRONGO (*Dicrurus ater*).

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stomach, intestine, and cloaca. There are no teeth, and the beak is employed for holding or tearing the prey, climbing, or as an organ of touch, etc. The tongue is hard and horny and is rarely an organ of taste (except in parrots where it is soft); it is chiefly used as an organ of prehension Salivary glands are present, but they are of small size and simple structure. The gullet is usually very long. In the flesh-eating and grain-eating birds the gullet is dilated into a pouch which is called the crop, and is so situated on the lower part of the neck, just in front of the merry-thought. The food is detained in it for a longer or shorter period before it is submitted to the action of the proper digestive organs. The gullet opens into the stomach, which opens into a muscular cavity, called the gizzard, and this opens into the small intestine. The walls of the gizzard may be thin or muscular in the case of birds whose hard food requires crushing; the food in the latter case being supplied in small amounts from the crop, just like grain to the crushing stones of a mill. The grinding action of the gizzard is further assisted by the small pebbles and gravel which, as is well known, so many birds swallow. These pebbles take the place of teeth and are necessary to the bird's health. Birds of prey and many insectivorous birds, including the ordinary crow, have a habit of rejecting by the mouth the undigestible portion of their prey in the form of a pellet. By examining these pellets the kind of insects preyed on by the insectivorous birds can be discovered. The intestine extends from the gizzard to the cloaca and is short. The ducts of the generative and urinary organs open into the cloaca.

Respiration is very extensive and active in birds, and this accounts for their high blood temperature and is due to the presence, in addition to the lungs, of a series of air-receptacles which are scattered through various parts of the body and to the interior of many of their bones. These are filled with air in flying birds and are absent in the bones of birds which do not fly, as the Penguins. The lungs are two in number, of a bright red colour and spongy texture, and they differ from those of mammals in not being suspended freely in the body cavity, but are attached to the dorsal wall and sunk in interspaces of the ribs. The diaphragm separating the thoracic and abdominal cavities is not complete as in mammals. The heart in all birds consists of four chambers, and the two sides are completely separated from one another. As regards

the structure of the heart and the great vessels and the course of the blood, birds agree with mammals. The heart of birds differs from reptiles in consisting of two sides, each composed of an auricle and ventricle, the right side being wholly concerned with sending the venous blood to the lungs and the left side with sending the arterial blood to the body. In all reptiles, on the other hand, the two circulations, namely, that through the lungs and that through the body, communicate with one another either in the heart itself or close by; so that both lungs and body are supplied with a mixture of venous and arterial blood. The urinary organs of birds consist of two elongated kidneys, which open by means of their ducts into the cloaca into which the termination of the intestine and the ducts of the reproductive organs also open. As a general rule, the female bird is provided only with a single ovary—that on the left side—and all birds without exception are oviparous, *i.e.*, lay eggs. The egg is always enclosed in a calcareous shell and is mostly developed, after being laid, by the process of incubation or "brooding," a process for which birds are specially adapted in consequence of their high temperature. The young bird, when ready, perforates the shell by means of a temporary calcareous excresence developed upon the point of the upper mandible of the bill. In some birds, mostly those which live upon the ground, the young are "active," the young being able to run about and look for food as soon as they emerge from the egg, as seen in the fowl and duck. In most birds, however, the young are helpless and require to be fed by their parents for a longer or shorter time, as in the case of the pigeon, cormorant, the common song-birds, etc. In this case the birds often build elaborate nests to bring up their young in. A rare case is that in which the young are produced as independent and full-fledged young birds at once.

As regards their nervous system, the brain of birds is larger in proportion than that of reptiles, but it has not the folds and convolutions of the brain of the mammals. The organs of sense, with the exception of touch and taste, are well developed, sight being generally acute. The eyes in birds are generally well developed and are always present. Eye-lashes are usually absent, but in addition to ordinary upper and lower eye-lids, birds possess a third transparent eye-lid which can be drawn across the eye. Except in owls, there is no external ear.

Fig. 342.

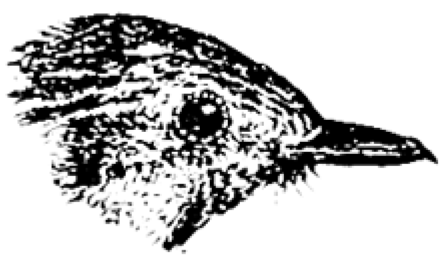

Fig. 343.

342. THE LONG-TAILED GRASS-WARBLER (*Laticilla burnesi*)

343. THE INDIAN GREY SHRIKE (*Lanius lahtora*)

Flight is performed by all birds by repeated strokes of the wing, and some, such as ducks, only progress in this way, while others indulge in longer or shorter intervals of sailing or soaring and this power of floating flight is sometimes greatly developed, enabling the bird to reach great heights, as may be seen in the ordinary Indian Vulture.

A few words are necessary on the subject of the migrations of birds. In temperate and cold climates, only certain birds remain constantly in the same region in which they were originally hatched. Those which do so are called Resident Birds, examples being the common Indian Crows and Mynas. Woodpeckers are also residents, although it is probable that some, *e.g.*, the Himalayan species, may shift their quarters at different seasons. Other birds, such as the Indian Pitta, migrate from place to place, their movements depending on the scarcity or abundance of food in any particular locality. These are called partial migrants. Many of the water-birds move about when marshes and tanks dry up or are filled in the monsoon. Other birds, however, at certain seasons of the year, undertake long journeys, usually uniting for this purpose into flocks. These birds are called Migratory Birds, and some Indian swallows, quail, snipe, etc., are examples of such birds; there are species of each of these, however, who are residents. The movements of migratory birds depend apparently chiefly on the available food-supply, this being the primary cause of the journeys they undertake.

Insectivorous birds are of some importance to the forester, and it will often be found useful to encourage them in nurseries and plantations by setting up artificially prepared nests, such as small boxes on poles, or upright hollow bamboos with holes cut in them just above the nodes, etc. Fruit-eating birds are also useful since they take into their intestines considerable numbers of the seeds of the fruits on which they feed, and these seeds being undigested are passed out with other refuse. The seed of forest trees may be widely scattered in this manner. A good example of this action of birds can be seen in the Changa Manga Plantation where the rosy pastor, which assembles in enormous flocks to feed on the fruits of the mulberry trees in the plantation, has distributed the seed and consequently planted up considerable areas in this manner. On the other hand this bird is a serious pest in fields of grain.

Certain species of birds have been domesticated for ages by man, examples of which are the common Fowl, Pigeon, Duck, etc., and many species are eaten by him.

The birds more especially characteristic of the Indian or Oriental region are the Pea-fowl, Jungle-fowl, Babblers, Hornbills, and Sun-birds, whilst the Broadbills are confined to the Indian region alone.

SUB-CLASS.—CARINATÆ.

The Sub-class Carinatæ is the only order which will be considered here as it includes all Indian birds. The birds in this sub-class vary immensely in external structure and habits; all flying birds are included here The keel of the sternum is well developed and the quadrate articulates with the skull by two heads. The males are generally larger than the females. For our purpose it will be sufficient to consider the following orders of birds without going further into the very difficult question of the classification of the sub-class.

ORDER I.—PASSARES.

This is by far the largest group of birds containing more than 5,000 species; they are usually of small size, the crows being the largest forms. The birds agree in having helpless young, naked or nearly so, and a very characteristic foot, with three toes before and one behind, the latter with its claw being usually larger than any of the front ones (*cf.* fig. 338). The whole limb is either coarsely scaled or has the shank covered in front by a single plate. The rest of the body and especially the beak, exhibits great variation in form. The habits of the Passerine birds vary greatly, some being insectivorous, and some vegetarian, but the majority are mixed feeders; some, like the Shrikes, are predaceous and attack small Vertebrates. Most frequent trees and bushes, but *Larks* live on the ground like *Game-birds*, and *Swallows* on the wing-like *Swifts*; the *Wag-tails* paddle at the water's edge, and the *Dippers* are aquatic, diving under water to obtain their food. The nest similarly varies in position and construction, being on trees or bushes, in holes or on the ground; it is generally well made; and amongst the Passerines the best examples of bird architecture are to be found, such as the nests of the tailor and

Fig. 344.

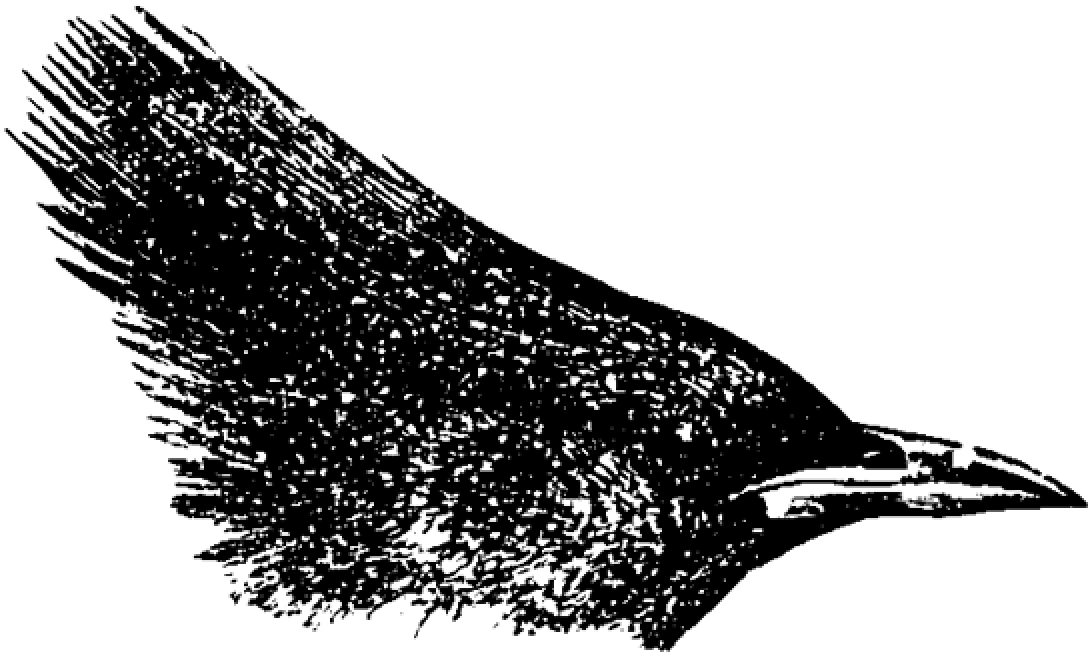

Fig. 345

344. THE HEAD OF THE ROSE-COLOURED STARLING (*Pastor roseus*).
345. THE COMMON MYNA (*Acridotheres tristis*).

Fig. 346.

Fig. 347.

346. THE GOLDEN-BACKED WOOD-PECKER (*Brachypternus aurantius*) and nest-hole.
347 HEAD OF THE COMMON INDIAN GREEN BARBET (*Thereiceryx zeylonicus*).

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weaver-birds, etc. The eggs are usually coloured or spotted, but may be plain, or even pure white. Amongst the birds included here are the house and jungle crows (fig. 336), magpies (fig. 337), jays, tree-pies, bulbuls (fig. 340), drongoes (king-crow) (fig. 341), mynas (fig. 345), and sparrows which feed on a mixed diet; the starlings, of which *Pastor roseus* (fig. 344) is a representative, also belong to this group. This latter bird appears in immense flocks in the Changa Manga Plantation in April when the mulberries are ripening and feeds upon them. The king-crows (Oranga), wag-tails, tits, thrushes, babblers (fig. 339), swallows and warblers (fig. 342), which include the tailor-bird, are insectivorous, as also the shrikes (fig. 343) which feed chiefly on insects but occasionally on small vertebrates, and so may do harm.

The weaver birds belong to the family *Ploceidæ*. *Ploceus baya*, the Baya or common weaver bird constructs the well-known hanging flask-shaped nests of grass. These are strongly woven, and are suspended from a branch of a tree. A peculiar interest attaches to these nests as Mr. Perrée, I.F.S., has recorded that they are a source of considerable danger in the fire season in Assam (Goalpara). During a fire they catch light at the base, the few threads by which they are suspended quickly burn through, and the nest then resembles a fire baloon and may be blown many hundred yards across cleared fire-lines into areas which would be otherwise safe from infection. It is recommended that in such localities all weaver bird nests should be cleared from trees on fire lines and closely adjacent to such.

ORDER 2.—PICI.

The woodpeckers are the chief birds of importance in this group. They are birds of medium size with longish, stout, chisel-tipped bill, stiff wing, tail, and short legs with toes arranged in pairs, the outer or fourth toe being turned backwards with the first which is often small. The tongue is long and worm-like, horny and barbed at the tip, and is used as a probe and spear for capturing insects in crevices. The plumage is often black and white, sometimes olive green or brown, with in many cases bright red or yellow tufts on the head, etc. The eggs are white, the nest being in a hole hewed out by the parents in wood, and the young are hatched naked. They are solitary

birds and seldom perch, running on the stems and branches up which they climb by a series of hops, pressing their hard tails against the bark. They feed on wood-boring insects and are thus of great use to the forester. The holes they make in trees can be seen in coniferous trees in the Jaunsar-Himalayan forests, a species boring horizontal series of holes all up the stems of the tree.

Brachypternus aurantius, the golden-backed woodpecker (fig. 346), is common in the forests of India. It is a bold, noisy bird, the most familiar of the woodpeckers, being often found in the neighbourhood of villages on the outskirts of forests. It feeds upon the grubs and pupæ of the sál pest *Hoplocerambyx spinicornis* in Eastern Bengal and Assam. *Tiga javanensis* is the species which feeds upon the caterpillars and pupæ of the bee hole-borer of teak (*Duomitus ceramicus*).

ORDER 3.—ZYGODACTYLI.

The first and fourth toes are directed backwards, but the tongue is of ordinary structure and not protrusible. The sternum is much broader in proportion to its length than in the *Pici*.

The Barbets, including the common green barbet (*Thereiceryx zeylonicus*, fig. 347) and the coppersmith, are members of this order. Fig. 348 shows the head of the crimson breasted barbet or coppersmith (*Xantholæma hæmatocephala*).

ORDER 4.—ANISODACTYLI.

Perching birds, of which *Coracias indica* (fig. 349) is the commonest species, with short legs, and toes placed three before and one behind; the anterior toes being usually more or less united in a common skin; the bill is always rather large, sometimes very large; wings are powerful though short. The young are helpless and naked, and the nest is made in a hole, the eggs being white in the majority of cases. Most of these birds live on animal food, the prey being captured by sudden darts from the perch, but some eat fruit and others search for their food. The rollers and bee-eaters (fly-catchers), *Merops virides* being the common green Indian bee-eater, feed on insects, swooping down on them from their perches; the Hoopoes feed on the ground on insects which they probe for with their long beak. Fig. 351 shows the head of *Upupa epops*, the European Hoopoe, an inhabitant of the Himalayas, migrating to the plains of the upper half of

Fig 348.

Fig. 349.

Fig. 350

348. HEAD OF THE COPPERSMITH OR CRIMSON-BREASTED BARBET (*Xantholæma haematocephala*).

349. HEAD OF THE INDIAN ROLLER (*Coracias indica*).

350. THE GREAT HORNBILL (*Dichoceros bicornis*)

Fig 351

Fig. 352.

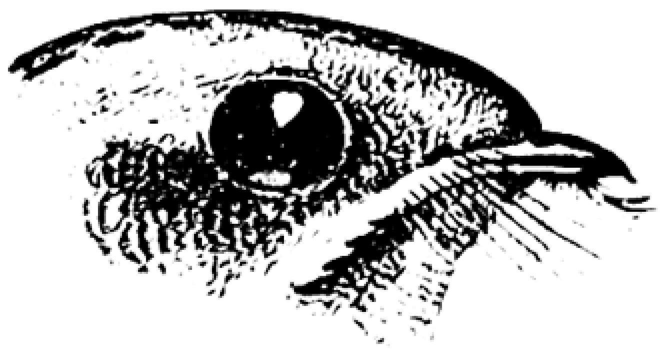
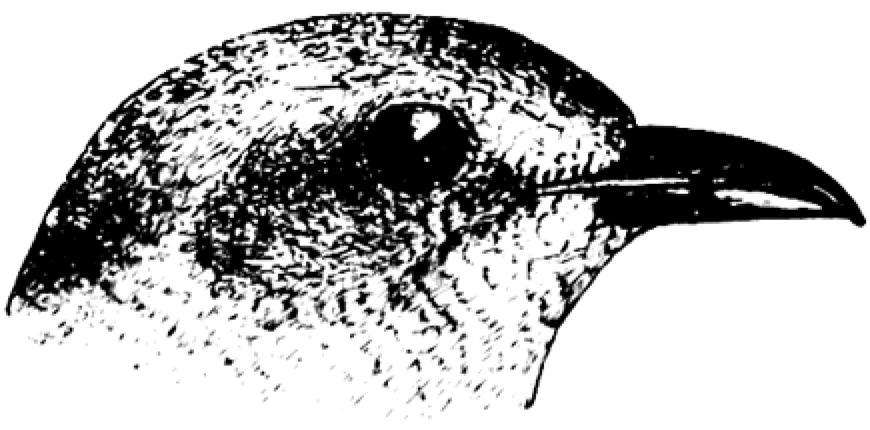


Fig. 353.



351. HEAD OF EUROPRAN HOOPOE (*Upupa Epops*) $\frac{2}{3}$.
352. HEAD OF COMMON INDIAN NIGHTJAR (*Caprimulgus asiaticus*) $\frac{1}{1}$.
353. HEAD OF COMMON HAWK-CUCKOO (*Hierococcyx varius*) $\frac{1}{1}$

to face page 191.

India in the cold weather. The king-fishers are brilliantly plumaged birds, for the most part living on rivers and streams, and feeding on fish; one of the commonest of Indian king-fishers, however, *Halcyon smyrnensis*, lives as a rule away from water and feeds upon insects. *Pelargopsis gurial* is a brown-headed king-fisher common on streams and rivers in well-wooded countries. The hornbills feed on fruits and on such small animals as they can capture, and rarely descend to the ground. The female hornbill before sitting upon her eggs walls herself up in her nest with mud in a hole in a tree, a slit only being left through which the male feeds her—*vide* fig. 350. There are several species in Indian forests, of which *Dichoceros bicornis*, shown in the illustration, is a common one in the country.

ORDER 5.—MACROCHIRES.

This group comprises the swifts, humming-birds, and night-jars. The birds have powerful wings and small weak feet, with three toes in front and one behind, the latter in swifts being more or less reversible. They move but little on foot and seek their insect food in the air. The gape of the bill is generally very wide, the bill itself being very small, except in humming-birds where it is long. The young are naked, except in night-jars where they are covered with fluff, and helpless, and the eggs white, except in night-jars, where they are mottled and laid usually two at a time on the ground, without a nest being made. Fig. 352 shows the head of the common Indian night-jar, *Caprimulgus asiaticus*. The swifts resemble swallows, but may be distinguished by having only ten tail-feathers and very different feet, and they do not settle or perch upon the ground, as they are only able to cling and crawl. The humming-birds are confined to America.

ORDER 6.—COCCYGES.

Birds of moderate size and mostly of arboreal habits; the toes are in pairs, the fourth, as well as the first, being turned backwards. The sexes are usually alike. The cuckoos are the chief birds of this group, and they are of world-wide distribution, except in cold climates. In temperate regions, including the Himalayas, they are migratory.

They have a curved bill of medium length and a more or less wedge-shaped tail. Some cuckoos are parasitic, laying their eggs in the nests of other birds; when this has taken place the young cuckoo, as soon as hatched, ejects its bed-fellows by getting under them and shouldering them out. The common Indian Koel (*Endynamis honorata*, fig. 354) lays its eggs in the nests of crows which consequently hate it. The Bush Cuckoos, of which the common Crow-pheasant (*Centropus sinensis*) is an example, build a rough nest and rear their own young. The eggs of cuckoos vary in colour, and their young are naked, or nearly so. A few species feed on various vertebrates, such as snakes, toads, etc., but the majority are insect-feeders. The common cuckoo devours hairy caterpillars with impunity, these latter being ordinarily left alone by other birds; these it eats in such quantities that its stomach becomes lined with an interior coat of fur. The Koel eats fruit only. The Hawk-Cuckoo (*Hierococcyx varius*), so-called from its mimicking the Shikra-Hawk, is the well-known "Brain-fever bird." It lays its eggs in the nest of various babblers. Fig. 353 depicts the head of this bird.

ORDER 7.—PSITTACI.

A large and distinct group, containing the easily recognised parrots. The bill is very short and strongly hooked. The toes are in pairs, the outer being turned backwards, and they, as well as the shanks, are covered with granular scales. The tongue is fleshy. Parrots are vegetable feeders, living on grain, fruits, roots, and honey, etc.; they almost invariably nest in holes in trees, etc., generally excavated by themselves, no nest being made. The eggs are always white, and the young are helpless and usually naked. The plumage is remarkable for its brilliancy, green being the commonest hue, and of great protective value, considering the arboreal habits of the group; for parrots chiefly live in trees, where they clamber about from branch to branch, laying hold with their bill as well as with their feet. Some forms feed on the ground. Their flight is powerful and more rapid than that of most land birds. They are usually found in flocks. They use the foot as a hand in feeding, being most wasteful feeders, and are usually great pests to grain and fruit crops.

Fig. 354.

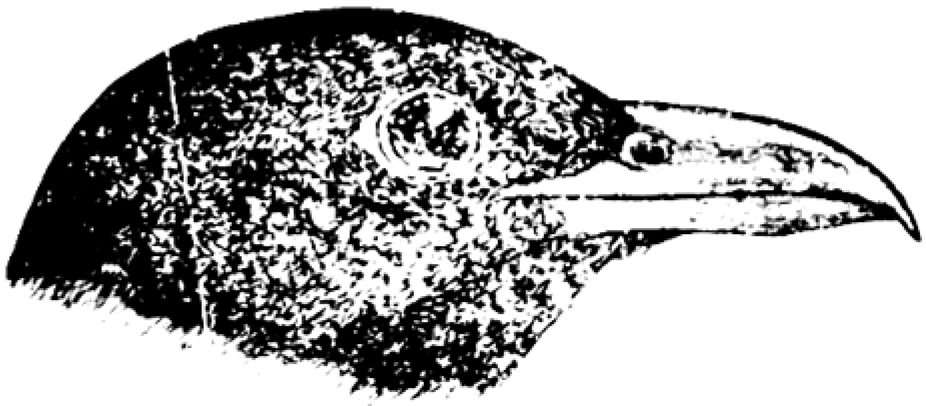
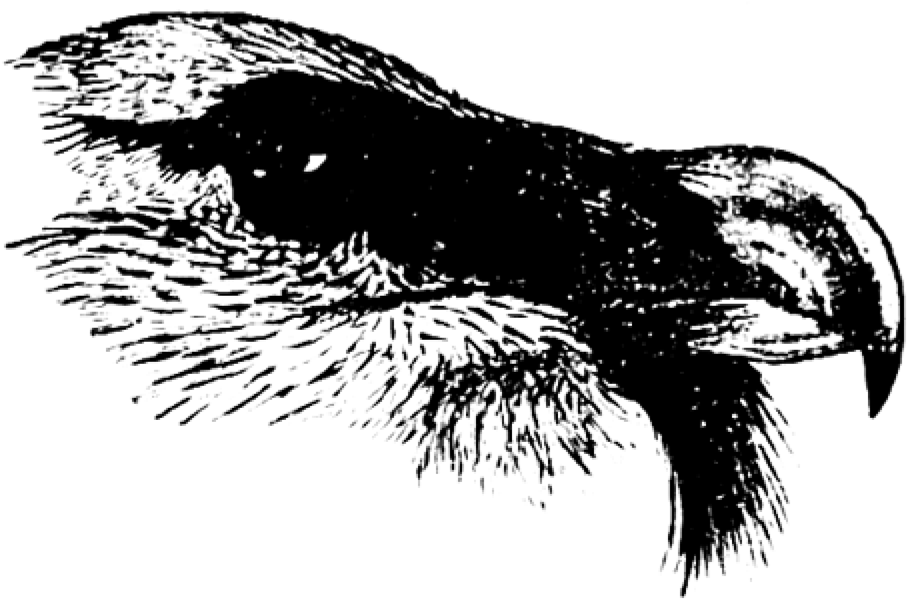


Fig. 355.

Fig. 356.

Fig. 357.



345. HEAD OF THE INDIAN KOEL (*Eudynamis honorata*) ¼.
355. HEAD OF THE ROSE-RINGED PAROQUET (*Palaeornis torquatus*) 1/1.
356. HEAD OF (*Asio accipitrinus*,) THE SHORT EARED OWL ½.
357. HEAD OF THE BEARDED VULTURE (*Gypaetus barbatus*) ¼.

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Palaeornis torquatus, the rose winged paroquet (fig. 355), is the commonest of the Indian parrots. It lays about 4 white eggs between January and May. It abounds near towns and villages and cultivated land, flying about in large flocks and committing an immense amount of damage by pilfering grain and fruit.

ORDER 8.—STRIGES (Owls).

The owls which comprise this group are in habits nocturnal. They have a hooked bill, and feet armed with powerful talons. The plumage is soft and full, and generally mottled drab or chestnut in colour; the eyes look forwards and in some are surrounded by a disk of bristly feathers, meeting over the bill which is thus partly concealed; the whole face is often surrounded by a ruff. They perch with the outer toe turned backwards, the hind-toe and claw being small. Owls also generally have bristles on the toes, and both these and the shanks are often covered with small soft feathers. Owls have external ears, the opening being large and provided with a flap of skin. The erect tufts of feathers, the so-called "ears," found in some species are not the ears, but merely serve to increase the resemblance of the owl to the stump or tree on which it is perched during the day. Their food consists of small mammals and large insects, and occasionally fish. They attack and secure their prey whilst on the wing. The young are hatched helpless and downy, the egg being white.

In all countries owls have been looked upon with a certain amount of superstitious dread and aversion, doubtless due to their unpleasant cries at night; but they are really among the most valuable of birds, as they feed largely on and keep down rodent mammals and large injurious insects, and in this way do incalculable good.

A common owl met with in grass lands in Northern India is *Asio accipitrinus*, the short-eared owl (fig. 356). It is usually found in long grass and is often seen when such areas are beaten for game.

ORDER 9.—ACCIPITRES (Birds of Prey).

The Birds of Prey comprising this group are easily distinguished by their powerful hooked bill and by having the two outer toes at least connected at the base by a web. They are usually of large or

at least moderate size, and never display brilliant colours. The sexes are similar, but the plumage of the adults differs from the first feathers of the young. The latter are helpless nestlings clothed with down and are attended carefully by both parents. The nest is built on the ground, on trees, or on rocks, and the eggs are either spotted with red or are plain white. The Birds of Prey are essentially carnivorous, and as a whole are exceedingly useful, either as scavengers or as destroyers of vermin and insects. They occasionally do harm by attacking game, poultry, and young domestic mammals. The group includes the Vultures, Eagles, Kites, Hawks, and Falcons. *Gyps indicus* is the common long billed vulture. Fig. 357 shows the head of *Gypaëtus barbatus*, the bearded vulture of North Indian mountain ranges. *Aquila vindhiana*, the Indian tawny eagle (fig. 358), is a common species to be seen beating over woods and fields for small vertebrates or feeding upon a carcase. *Milvus govinda* (fig. 359) is the common pariah kite, one of the most useful scavengers in the country. There are numerous Indian harriers, hawks, and falcons; the head of *Falco jugger* is depicted in fig. 360.

ORDER 10.—COLUMBÆ (Pigeons and Doves).

The pigeons comprising this group are easily recognised by their small heads provided with a weak bill, soft and fleshy at the base, rather long necks and heavy bodies clothed in hard, close powdery plumage most commonly grey, dun, or green in colour. The legs are rather short, and the hind-toe well developed; there is no web between the front toes; the wings are powerful and the flight strong. The sexes are similar, and the young resemble the adults when fledged. The eggs never exceed two in number and are white. They are usually deposited in a rough open nest of sticks placed in a tree. The young are helpless and naked and are fed by both parents. Both sexes incubate and relieve each other at regular intervals. They are vegetarian feeders and are often very destructive to crops when they feed on seeds and grain; but many species live on fruit, and these hardly ever leave the trees. Pigeons are more or less gregarious. The group includes the ordinary pigeons which feed on the ground and roost in trees, the big imperial pigeon and green pigeon and the doves and all form good food for man.

Fig. 358.

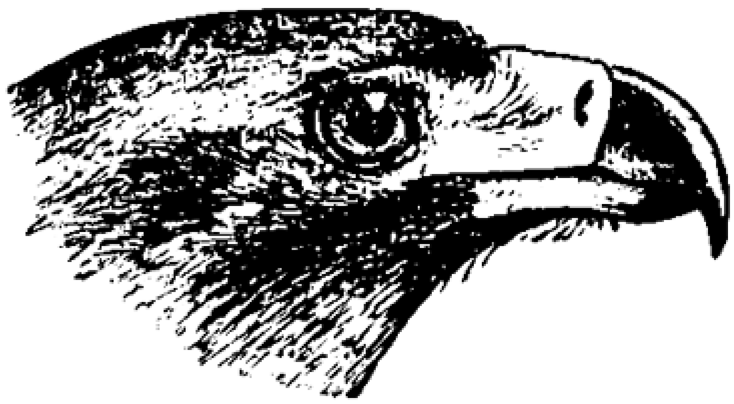

Fig. 359.

Fig. 360.

358. HEAD OF *Aquila vindhiana*, THE INDIAN TAWNY EAGLE, ½.
359. HEAD OF THE COMMON PARIAH KITE (*Milvus govinda*), ¾.
360. HEAD OF THE LAGGAR FALCON (*Falco jugger*), ⅔

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Fig. 361.

Fig. 362.

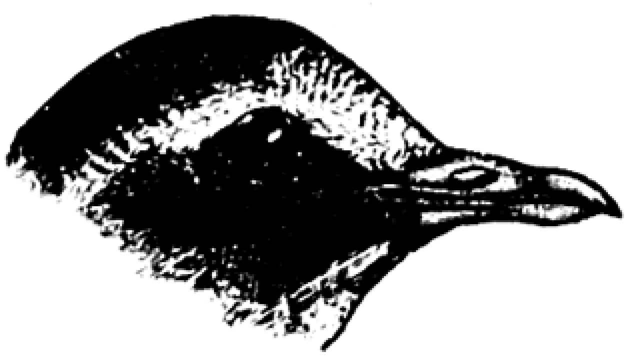
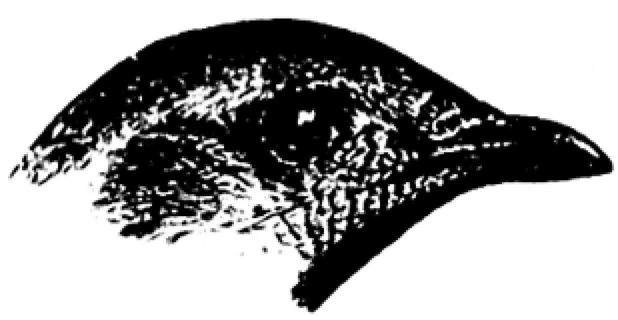


Fig. 363.



361. THE SPOTTED DOVE (*Turtur suratensis*).
362. THE BRONZE-WINGED DOVE (*Chalcophaps indica*), ½.
363. HEAD OF THE COMMON SAND-GROUSE (*Pteroclurus exustus*), ½.

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Chalcophaps indica (fig. 362) is the beautiful bronze winged dove found only in forests and damp thickly wooded parts of the country. It is generally solitary, is not shy, and can be found upon forest-paths feeding upon berries and seeds. *Columba intermedia* is the pigeon known as the blue-rock common in many parts of the country. It builds its nest in inaccessible cliffs. It is an excellent game-bird and is the originator of all pigeons. *Turur suratensis* (fig. 361) is the common spotted dove of the country.

ORDER II.—GALLINÆ (Game-birds).

The game-birds comprise this group and are easily known by their small heads, with short, curved beak, heavy bodies, short, rounded wings, and powerful feet, with three toes before and one behind, the front toes being webbed at the base, and the whole foot coarsely scaled. In feeding they are omnivorous, though partially vegetarian; their flight is heavy, and they seldom fly far; as a rule they pass most of their time on the ground, scratching amongst earth and leaves for their food. They are exceptional amongst birds in being often polygamous, and the males are often very pugnacious; the nest is very rough, and the numerous eggs, either plain or spotted; the downy young run at once on hatching out from the eggs. Game-birds are found all over the world where land-birds exist. Numerous species are found in India.

Grouse, with feathered legs and toes, are otherwise like Pea-fowl, Pheasants, Jungle-fowl, Partridges, Quail, which have bare legs, but the hind-toe small and raised above the level of the other toes. The sexes are often dissimilar, and when this is the case the species is usually polygamous. In such forms and in some others there are spurs on the shanks, and these are used for fighting.

Sand Grouse* are common in India, the common *Pterocturus exustus* (fig. 363) keeping to open country.

The common pea-fowl (*Pavo cretatus*) is a forest-loving bird, living in small parties and coming out into cultivation to feed in the morning and evening. In parts of India it is held as sacred. The pheasants are chiefly confined to the mountains, such beautiful

* For convenience I have included the Grouse in Gallinæ. Their usually accepted position is one between *Columba* and *Gallinæ* as a separate Order, Pterocletes.

species as the Argus, Polyplectron, the Cheer pheasant (*Catreus wallichi*, fig. 364), Koklas, the Kalig pheasants (fig. 365), etc., being well known. *Gallus ferrugineus* is the red jungle-fowl of India, a grey species, *G. sonnerati*, being found in the western and southern parts of the country. Coturnix or quails are also plentiful, as are the partridges (*Francolinus*), such as the Chukor, Sessee, black, painted, and grey (fig. 366), etc.

The Megapodes, which belong to a sub-order, resemble small turkeys in appearance, and their breeding arrangements are curious, as they lay their eggs and bury them in a mound of rubbish and leave them to hatch out in a similar manner to reptiles. The young emerge as *full-fledged* birds, able to run and fly almost immediately. Most of these Megapodes inhabit Australia, one species, however, being an inhabitant of the Nicobars.

ORDER 12.—GRALLÆ (Rails, Cranes, Bustards).

This order resembles in some respects the Anisodactyli. The legs are long and part of the tibia is bare, the hind-toe when present being bare. The young in most (except in Heliornis) are hatched covered with down and are able to run almost immediately. They all lay double-spotted eggs, *i.e.*, one set of spots dark and distinct and the other purplish or grey and indistinct.

The rails, corn-crakes, and coots have numerous representatives in India. They are marsh birds in general living amongst reeds or grass. The food is chiefly vegetable. *Rallus indicus* (fig. 367) is the common Indian water-rail. *Grus communis* is the common crane found in the northern half of India in the cold weather. *Anthropoides virgo* is the well-known demoiselle crane (fig. 368). The bustards and floricans also belong to this order.

ORDER 13.—LIMICOLÆ (Plovers, Snipe, Curlew, etc.).

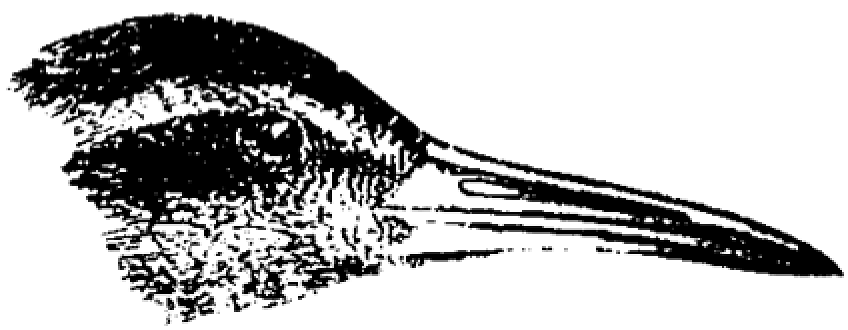
The bill varies greatly, but is usually slender, and the nostril is situated in a groove or depression on one side. The tibia is generally naked for some distance above the tibio-tarsal joint. The wings are as a rule long, the birds being strong fliers. Many are migratory. Plovers are common in India. *Cursorius coromandelicus* (fig. 369) is the brownish black bird seen running quickly about in small

Fig. 364

Fig. 365.

Fig. 366.

Fig. 367



364. HEAD OF THE CHEER PHEASANT (*Catreus wallichi*), ½.
365. HEAD OF THE WHITE-CRESTED KALIJ PHEASANT (*Gennaeus albicristatus*), ¼.
366. HEAD OF THE GREY PARTRIDGE (*Francolinus ponaicerianus*), ¼.
367. HEAD OF THE INDIAN WATER-RAIL (*Rallus indicus*), ½.

Fig. 368.

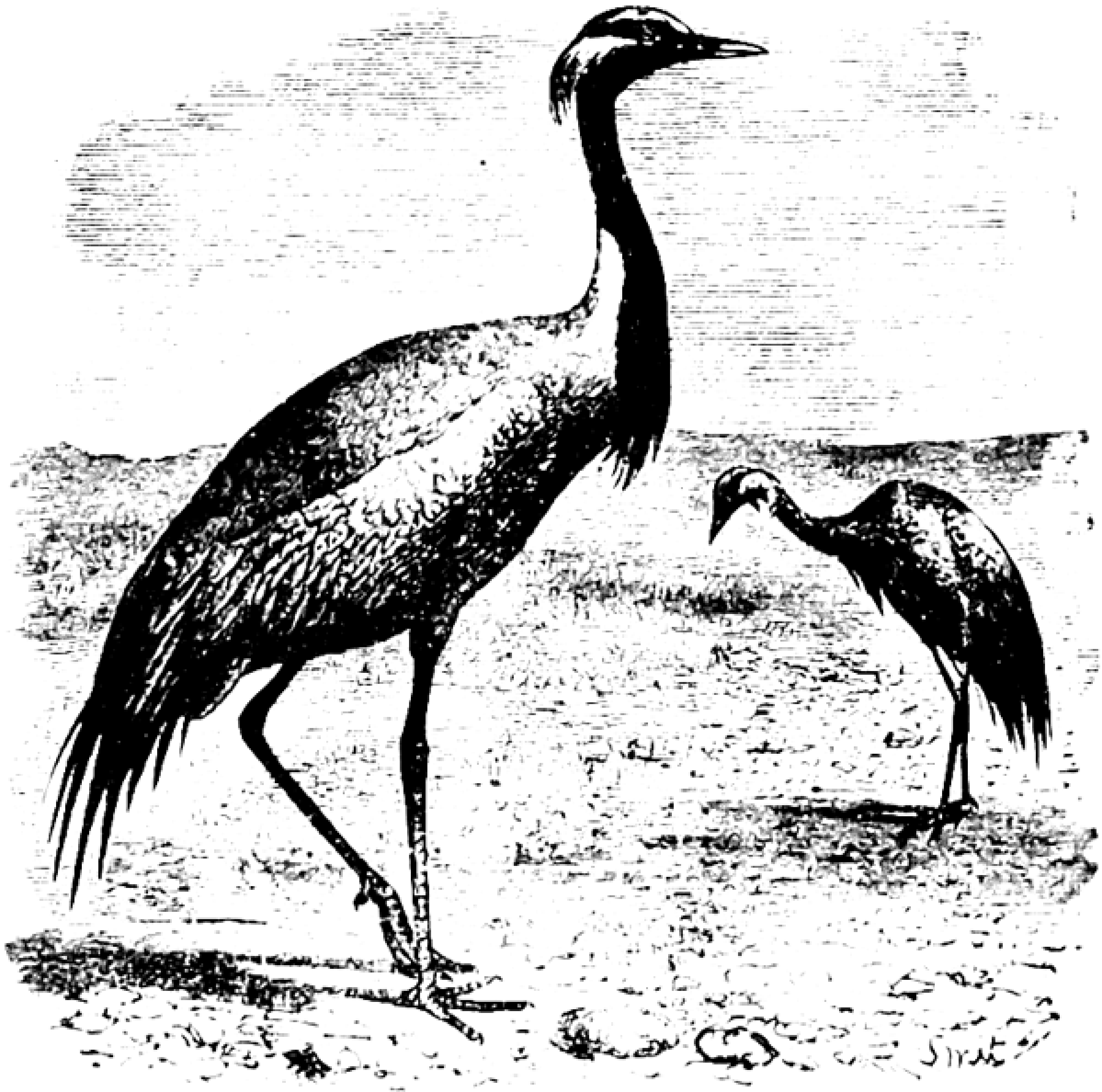
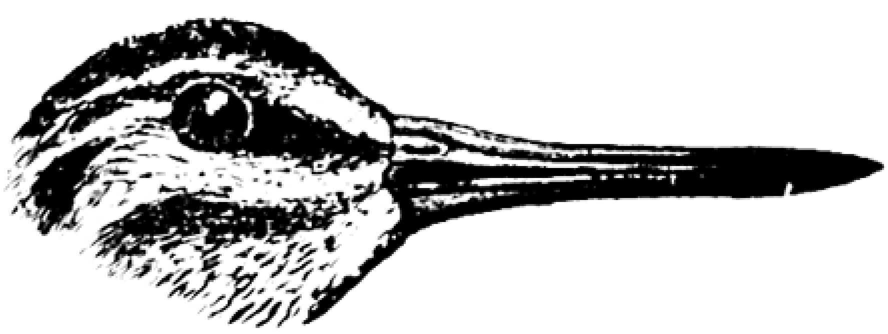


Fig. 369.

Fig. 370



368. THE DEMOISELLE CRANE (*Authropoides virgo*).
369. HEAD OF THE INDIAN COURSER (*Cursorius coromandelicus*), [illegible].
370. HEAD OF THE JACK SNIPE (*Gallinago gallinula*), $\frac{1}{1}$.

[To face page 199.

parties on open sandy or stony ground. Curlews, of which there are two Indian species, are birds with long curved bills frequenting the sea-shore or tidal estuaries. Sand-pipers, godwits, wood-cock, and snipe (fig. 370) belong to this family.

Note.—The gulls and terns, belonging to the Order Gaviæ, will not be considered here. They are water and marsh birds.

ORDER 14.—STEGANOPODES (Pelicans, Cormorants, etc.).

Large birds or of medium size which are at once distinguishable by having all the four toes webbed together, though the first is directed backwards or sideways and is of use in perching in the ordinary way. The legs are always short, but the general form and that of the bill varies considerably; the latter has the nostrils almost obliterated in the adult. These birds live by fishing, pursuing their prey, however, in different ways; they usually build nests for the reception of their young, which are helpless nestlings, naked at first, but acquiring down before their regular feathers. The eggs are few and usually unspotted and covered with a peculiar chalky coating. The sexes are similar, but the young in first plumage are very different. The birds fly well and perch on trees more than other water-fowl, the large hind-toe enabling them to grasp the branches. The Indian members of the group mostly build in trees. On account of the great destruction of fish effected by these birds they are somewhat injurious, although the young are used as food in many countries. The Pelicans are large birds with a pouch on the under-side of the lower beak. They are found on marshes, backwaters, or on the sea, and feed entirely on fish. The cormorants and snake-birds are the most familiar birds of this group and feed by diving, swimming very low in the water. Fig. 371 shows the head of *Phalacrocorax javanicus*, the little cormorant which is common throughout India.

Note—The Petrels (Order *Tubinares*) will not be considered here.

ORDER 15.—HERODIONES (Ibises, Spoonbills, Storks, Herons, and Bitterns).

This comprises a number of usually large wading birds resembling Cranes and Limicolæ in having long legs with usually more or less

of the tibia bare above the back, of slight build with powerful beaks and well-developed hind-toes. They perch a great deal and usually build in communities in trees, the eggs being few and usually spotless and the young helpless though downy, and are fed by the parents. The sexes in adults resemble one another, though they may have a special breeding plumage, but the young, when first fledged, are very different from the parents. Birds of this group are found all over the world, though they are more numerous in hot climates; they are carnivorous, especially devouring fish and are themselves seldom used as food. They are far less active on their feet than other waders, though excellent fliers. The Ibises, with more or less bald heads, build nests in trees and lay plain blue or spotted eggs. The Herons, Bitterns, and Egrets are birds varying in size from that of a crane to that of a myna, but all display a general similarity of build and habits. These birds perch freely, walk but little, often watching for their prey for a long time together, and draw their necks in when flying. They are dangerous to handle when wounded, as they aim at the eye of the aggressor when darting out the beak to attack. A distinct and handsome breeding adornment of ornamental plumes is often developed, and the white filmy ones of the egrets are much valued, being known as "Osprey." Most of the Indian Herons are resident in the country, and one of them, the paddy-bird, is the commonest bird in the country. The eggs of herons are sea-green or white, without spots, and the nest is usually placed in trees or rushes. *Ardea cinerea* is the common heron, shown with young in fig. 372. *Bubulcus coromandus*, the cattle egret, commonly known as the 'paddy-bird' (fig. 373), is a constant attendant on cattle and feeds mainly on insects attracted by cattle, and on grasshoppers.

Note.—The common flamingo to be found in salt marshes in Sind, Rajputana, belongs to the Order *Phœnicopteri*.

ORDER 16.—ANSERES (Ducks, Geese, and Swans).

The three anterior toes are united by webs extending to the ends of the digits; the hind-toe is always present, but is short and articulated to the tarsus higher up than the other toes. The bill is more or less depressed and flattened. The tongue is large and fleshy. All the species are monogamous, and the majority build nests

Fig. 371

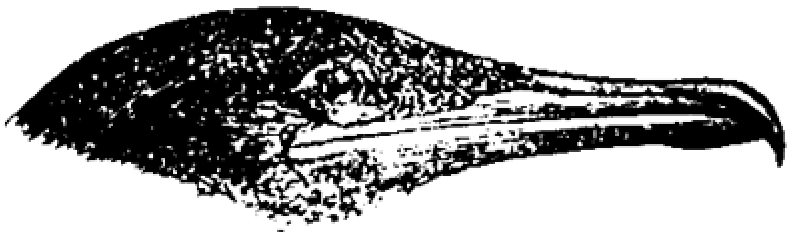


Fig. 372.

Fig. 373.

Fig. 374.

371. HEAD OF THE LITTLE CORMORANT (*Phalacrocorax javanicus*) ½.
372. THE COMMON HERON (*Ardea cinerea*) AND YOUNG.
373. HEAD OF THE CATTLE EGRET (*Bubulcus coromandus*).
374. HEAD OF THE BARRED-HEADED GOOSE (*Anser indicus*).

to face page

of grass and rushes on the ground; the eggs are numerous, white, buff, cream, or pale green in colour. The young are hatched covered with down and are able to run or swim at once. The swans and geese are common. Fig. 374 shows *Anser indicus*, the Barred-headed Goose. The ducks and teal are very numerous. *Casarca rutila* is the Brahminy duck. The Order *Pygopodes* contains the Grebes.

CHAPTER XIV.

CLASS V.—MAMMALIA (Mammals).

The Mammalia include all the ordinary quadrupeds and may be shortly defined as comprising vertebrate animals in which some part or other of the skin is always provided with hair, and the young are nourished for a longer or shorter time by means of a special fluid—the milk—secreted by special glands called the mammary glands. These two peculiarities are of themselves sufficient to separate the mammals from all other classes of the vertebrates. In addition the following points should be carefully noted :—

(1) The skull is united with the spinal column by means of two articulating surfaces or condyles instead of one as in the Reptiles and Birds.

(2) The lower jaw consists of two halves, each composed of a single piece, and united in front. The lower jaw also is always jointed directly to the skull, and there is no quadrate bone.

(3) The heart consists—as in birds—of four distinct chambers, two auricles and two ventricles. The right and left sides of the heart are completely separated from one another, and there is never any direct communication between the blood sent to the lungs and that sent to the body. The red corpuscles of the blood are, generally, in the form of circular discs, and they never contain a nucleus.

(4) The cavities of the chest (thorax) and abdomen are separated from one another by a muscular partition which is called the diaphragm and is the chief agent in respiration.

(5) The respiratory organs are in the form of two lungs, placed in the chest, and never communicating with air receptacles situated in different parts of the body. In no case, and at no period of life, are gills present.

We have already considered the skeleton of a mammal in the Introduction and when describing vertebrates generally. It should

be borne in mind that the spinal column is divisible with few exceptions into the same regions as that of man. The divisions are—

(1) The neck in which the number of vertebræ are nearly always seven in spite of the great difference observable in the length of the neck, *e.g.*, in the giraffe and whale.

(2) The back or dorsal region in which the vertebræ are usually thirteen in number and may be more.

(3) The loins or lumbar region having usually six or seven vertebræ and rarely less than four.

(4) The sacral region in which the vertebræ are usually amalgamated to form a single bone.

(5) The tail or caudal region in which the vertebræ vary from four to forty-five and are usually freely movable upon one another.

It should be noted further that the thoracic cavity is always enclosed with ribs, the number of which varies with the number of dorsal vertebræ.

The fore-limbs are never wanting, but the hind-limbs are absent in some mammals, as, for example, in the Cetaceans and Sirenians.

Teeth are present in the majority of the animals, but are absent in Echidna, some whales, etc., and they are horny in the Duck-moles. In most other mammals (Echidna have no enamel) the teeth have their ordinary structure of dentine, enamel, and cement, these elements being variously disposed, the enamel being occasionally absent. The teeth are planted in distinct sockets. Many mammals have only a single set of teeth throughout life. In most cases, however the first set of teeth, the milk or deciduous teeth, is replaced in the course of growth by a second set of "permanent" teeth. No mammal has ever more than these two sets. Two parts may be distinguished in a tooth, the crown and the root. The root is the lower, usually narrower, part and is often split into several branches; it is destitute of enamel, but is covered with cement. The upper part is the crown and is enamelled, and is usually clearly demarcated from the root by a constriction. The teeth are divided into incisors, canines, premolars, and molars; the incisors are usually preceded by the milk-teeth in a young mammal and are those which are implanted

in the premaxillary bones and in the corresponding part of the lower jaw. The tooth in the maxillary bone, which is situated at or near to the suture with the premaxillary, is the "canine," as is also that tooth in the lower jaw which, in opposing it, passes in front of its crown when the mouth is closed; the teeth behind the canines are the premolars and molars. All these different kinds of teeth are not necessarily present, and as the teeth are important in separating the main orders of mammals from one another, their number is expressed by a dental formula; *e.g.*, the dental formula of a ruminant animal such as a sheep would be—

$$i.\,\frac{0-0}{3-3};\quad c.\,\frac{0-0}{1-1};\quad pm.\,\frac{3-3}{3-3};\quad m.\,\frac{3-3}{3-3}=32$$

i., *c.*, *pm.*, and *m.* represent the incisors, canines, premolars, and molars. The explanation is that the sheep has 32 teeth, as follows:—the short dashes between the figures indicate the teeth on two sides of the mouth, the upper line of figures represents the upper jaw; the lower line, the lower jaw. From the formula we see that the upper incisors and canines are wanting, and there are three premolars and three molars on each side of the upper jaw. In the lower jaw there are six incisors, two canines, and the same number of premolars and molars as in the upper jaw.

In the Introduction we have already considered the digestive nervous, etc., systems of a mammal.

CLASSIFICATION OF MAMMALS.

It will be sufficient for our purpose here to divide the Mammalia, in accordance with the way the young are developed, into the Oviparous Mammals, in which the young are not born alive but produced as eggs, and the Viviporous Mammals in which the young are born alive; these latter are divided into non-placental and placental mammals.

1.—*Oviparous Mammals.*

These mammals are supposed to connect certain extinct reptiles, which are said to have condyles resembling those of mammals, with Mammalia. The young are not born alive as is usual in mammals

but are laid as eggs. Nevertheless, the animals are genuine mammals as they are provided with hair and mammary glands; the nature of their blood and the structure of their lower jaw also include them in the class. On the other hand, they resemble amphibia, reptiles, and birds, in that the intestine terminates in a cloaca, and in the important point that they produce their young in the form of eggs which have a leathery shell.

ORDER 1.—MONTREMATA.

This order is important for our purpose. It contains the queer otter-like animals known as Ornithorhynchus (Duck-moles) and the Echidna on spiny Ant-eaters, both inhabitants of Australia.

II.—*Viviparous Mammals.*

In the viviparous mammals the egg-shell is always absent, and the ovum is of small size. The young are born alive.

(*a*) *Non-placental Mammals.*—In these, although the young are born alive, they are in such an imperfect state that the female is provided with an abdominal pouch or marsupium in which the teats are situated and in which the young are taken about in safety. This arrangement also enables the mother to fix the young on to the teats, they being quite unable to suck without this aid, and they remain unavoidably fixed in this position for some time.

ORDER 2.—MARSUPIALIA (Marsupials or Pouched Animals).

The leading characteristic of this order is the absence of a true placenta (nutritious apparatus), and the embryo is born in a very immature state as described above. The living animals comprised in this order are confined to Australia and America and are of little importance to the Indian forester.

They consist of vegetable-eaters, such as the Kangaroo and carnivorous animals, as, *e.g.*, the Bandicoots and American Opossums.

In the Kangaroos (Macropodidæ) the hind-legs are far longer and stronger than the fore, and with them, assisted by a powerful tail, the animal can perform long jumps. The canine teeth are small or absent, and there is only one incisor on either side of the lower jaw,

the molars having broad grinding crowns. The Phalangers, or so-called Australian "Opossum" are vegetable-eaters and live in trees.

The Bandicoots and true Opossums, the latter living in America, are carnivorous. They both have at least three small incisors on each side of the lower jaw. The canines are larger than the incisors. The Bandicoots (Perameles) are little rabbit-like Australian animals which live on insects and seem to fill the place held in the Old World by the Hedgehogs and Shrew-mice. The Opossums are all of small size with prehensile tails, and they mostly live in trees. They are confined to America.

(*b*) *Placental Mammals.*—The young are brought forth alive. They are nourished for a time within the body of the mother by means of a structure, called the "placenta," through which the nutrient materials of the mother's blood reach the young. Thus, when born, the young are capable of sucking their milk by their own exertions. All the higher animals are included here.

ORDER 3.—EDENTATA.

The order is characterised by the absence of teeth in the front of the jaw. In some, as in the case of the Indian forms, teeth are entirely wanting; when they are present, they are rootless, destitute of enamel, and similar to each other in shape, and with one exception there are no milk-teeth. They are all terrestrial or arboreal and resemble ordinary mammals in external form. They chiefly live in South America. The existing members of the order readily group themselves into five families—*Bradypodidæ* or Sloths; *Myrmecophagidæ* or Ant-eaters; *Dasypodidæ* or Armadillos; *Manidæ*, Pangolins or scaly Ant-eaters; and *Orycteropodidæ*, Aard-barks or African Ant-eaters. The Sloths are exclusively confined to South America, inhabiting the vast primeval forests of that continent. They spend their lives in trees, their feet being provided with extremely long, curved claws. The Armadillos are also confined to South America. They are burrowing animals, furnished with strong digging-claws and well-developed collar-bones. The upper surface of the body is covered with a coat-of-mail formed of hard, bony plates or shields, united at their edges. This shield is also present on the head and shoulders in two separate portions, and the animals are often

able to roll themselves up in a ball like a hedgehog when attacked, the whole of the exterior surface consisting then of the scaly armour.

The scaly Ant-eaters or Pangolins are exclusively confined to Asia and Africa. In them the body and tail are covered with flexible armour, composed of long plates or scales, overlapping like the tiles of a roof. They are burrowers and live entirely on ants and termites, the long extensile tongue being used for the capture of the insects. They roll themselves into a ball for defence and exhibit an enormous muscular power that defies any ordinary effort to unroll them. Owing to their scales they are often alluded to by natives as *Banrohu* (jungle carp). Fig. 375 shows *Manis javanica,* the Malay pangolin.

ORDER 4.—SIRENIA.

This order comprises only certain large marine mammals, known as Dugongs and Manatees. They agree with the next order, the Whales, in having the body adapted for an aquatic life, especially in the facts that the anterior limbs are converted into swimming paddles: the hind-limbs are wholly wanting, and the hinder end of the body forms a powerful caudal fin which is placed so as to strike the water horizontally and not vertically as in fishes. They differ from the Cetacea (Whales) in having the nostrils placed at the anterior part of the head and in having molar teeth with flat crowns adapted for vegetable food. Fleshy lips are present, the upper usually with a moustache, and the skin is covered with scanty bristles. There is a distinct neck. Dugongs live in the sea and feed on sea weeds. They are to be found off the coasts of the Indian Ocean and the north coast of Australia, and often attain a length of 18—20 feet. Fig. 376 shows the Halicore dugong, the common species of the Indian Ocean. Manatees live at the mouths of rivers and estuaries. They are found on the east coast of America and on the west coast of Africa.

ORDER 5.—CETACEA (Whales, etc.).

This order comprises the Whales, Dolphins, and Porpoises, and it is characterised by the complete adaptation of its members to a watery

Fig. 375.

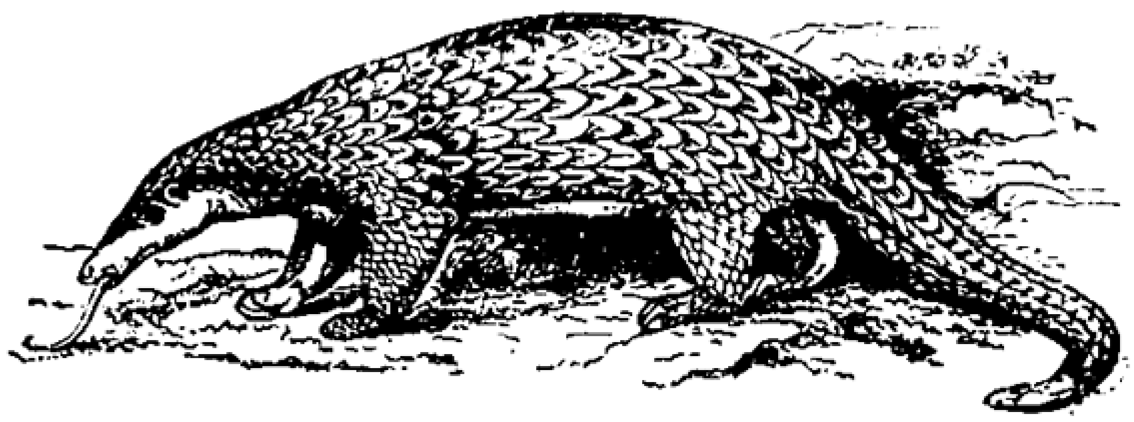


Fig. 376.

Fig. 377.

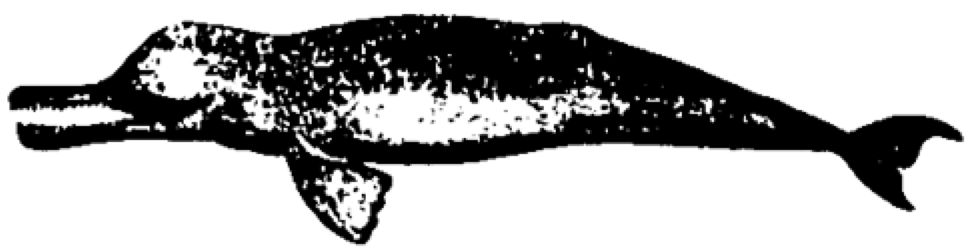
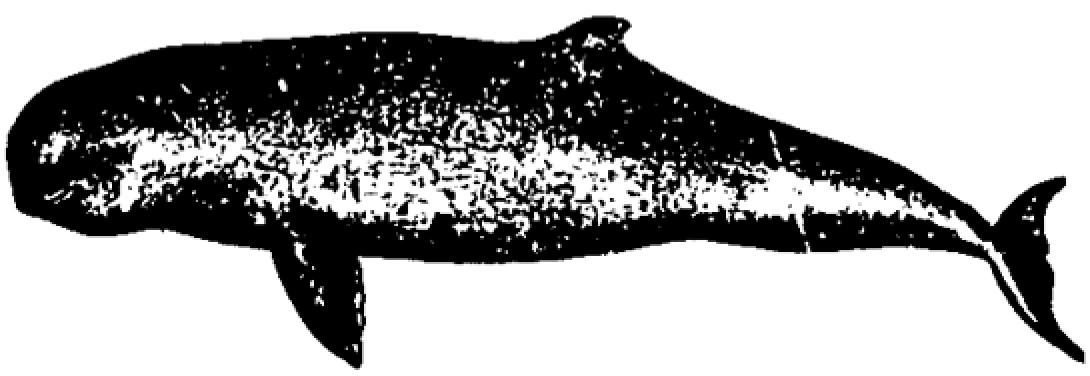


Fig. 378.



375. The Malay Pangolin (*Manis javanica*).
376. The Dugong (*Halicore dugong*).
377. The Gangetic Dolphin (*Platanista gangetica*)
378. The larger Indian Porpoise (*Orcella brevirostris*).

to face page 208.

life. The body is completely fish-like in form, the fore-limbs are converted into swimming paddles, and the hind-limbs are completely wanting; whilst the hinder end of the body forms an extremely powerful horizontal caudal fin. There is sometimes a dorsal fin as well. The nostrils may be single or double, but are always placed on the top of the head constituting the "blow-hole." Very few hairs are present. The head is large as compared to the body, and there is rarely a neck. The adult either has no teeth, or, if present, has only a single set, which are always conical in shape and are not divisible into distinct groups. All true Cetacea are carnivorous, living upon animal food. The most important of the Cetacea are the whalebone whales (*Balænidæ*) in which the adult is destitute of teeth, the place being taken by a series of transverse plates of whalebone which serve as a filter to separate from the sea-water the minute molluscs and crustaceans on which these enormous animals live. Whalebone and the whale-oil of commerce are obtained from these whales. Though an inhabitant of the sea, the whale is obliged to come to the surface to breathe, and in doing so it ejects from the blow-hole what looks like a column of water. The apparent jet of water is simply due to the condensation of the moisture which is contained in the expelled air. The Sperm Whale, *Physeter macrocephalus* (fig. 379), is a toothed whale, having numerous conical teeth in the lower jaw and a single blow-hole. The Dolphins and Porpoises (*Dolphinidæ*) have numerous conical teeth in both jaws, and the nostrils open by a single aperture on the top of the head. The porpoises are exclusively marine, and occur in all seas. Fig. 378 shows the large Indian porpoise (*Orcella brevirostris*). The dolphins are mostly inhabitants of the sea, but there are fresh-water forms in Southern America and Southern Asia. The 'Súsú,' *Platanista gangetica* (fig. 377), is the common dolphin of the Ganges, Brahmaputra, and the Indus.

ORDER 6.—UNGULATA (Hoofed Quadrupeds).

This order is often spoken of as that of the hoofed quadrupeds, and is one of the largest and most important of the orders of Mammalia. It includes the Hippopotami and their allies, pigs, camels, deer, antelopes and goats, oxen, sheep, tapirs and rhinoceroses and horses, and a vast number of extinct animals. The Hyraces and elephants

are also included in the order. The order is characterised by having the portion of the toe which touches the ground encased in a greatly expanded nail or hoof. There are never more than four full-sized toes to each leg, and owing to the presence of hoofs, the limbs are useless for grasping and are only of use in locomotion and in supporting the weight of the body. There are always two sets of teeth, and the molars have broad crowns adapted for grinding vegetable substances.

The whole order may be divided into the Ungulata Vera, containing the Sub-orders PERISSODACTYLA and ARTIODACTYLA, and a heterogenous assemblage of animals called SUBUNGULATA.

UNGULATA VERA.

In the typical Ungulata the feet are never plantigrade, and the functional toes do not exceed four.

SUB-ORDER.—ARTIODACTYLA.

This sub-order differs from the Perissodactyla in having the premolar and molar teeth usually not alike, the former being single and the latter two-lobed, the last molar being almost invariably three-lobed. The two median digits (3rd and 4th) are equal in size.

Suina.

Pattern of molar teeth not arranged in crescents. Upper incisors are present. The animals are not ruminant.

FAMILY.—*Hippopotamidæ* (Hippopotamus).

The *Hippopotamidæ* or Hippopotamuses form a small group of massive thick-skinned Ungulates, with four-toed feet. The common Hippopotamus inhabits all the gr at rivers of Africa, living upon plants and swimming and diving with great facility. The molar teeth have flat crowns; the canines are very large, and the lower ones form enormous tusks, with a chisel-shaped edge and form the principal weapons by which the animal defends itself.

FAMILY.—*Suidæ* (Pigs).

The *Suidæ* or pigs have usually four toes to each foot, though sometimes the hind feet have only three toes All the toes are hoofed,

but it is only two which support the weight of the body, the remaining toe or toes being placed at some elevation on the back of the foot. The snout is truncated and cylindrical, and is capable of extensive movement. The tail is very short. The molar and premolar teeth have tuberculated crowns. The pigs are miscellaneous feeders. The most important and best known is the wild boar (*Sus scrofa*) from which most of our domestic pigs are descended.

The usefulness or otherwise of the pig to the forester depends in a great measure on the elevation at which it is living. Thus in the coniferous forests in the Himalayan region the animal is probably of considerable use, as in its search for seeds, roots, etc., it ploughs through the thick, matty mass of needles and seedlings present in these forests, and this exposes the soil and enables the seeds to germinate. Thus, in valuable coniferous forests the harm it does by destroying young seedlings, etc., is probably more than counterbalanced by the good done in assisting regeneration. In the plains, however, where this necessity does not exist, pigs must be looked upon as the enemy of the forester owing to the damage they are capable of doing in plantations, nurseries, and to the large amount of seeds, etc., consumed by them. They are also particularly harmful to crops.

NOTE.—The Peccaries (Family *Dicotylidæ*) are pig-like animals with a snout as in *Suidæ*. They are confined to the New World.

Tylopoda.

Includes the Camels of the Old World and the Llamas of South America. The premaxilla has the full number of incisor teeth when young, the outermost only being persistent in the older stages of life. Canines are present in both jaws. The hinder part of the body is much contracted, the femur being long and vertically placed so that the knee joint is low down.

FAMILY.—*Camelidæ* (Camels).

The Camelidæ include the Camel and Dromedary of the Old World and the Llamas of the New, and is characterised by having no horns, by having two incisors in the upper jaw, and a pair of canines in both jaws, whilst the first premolar tooth in both jaws (or

in the upper one only) is conical in shape, and is placed at some distance in front of the other back teeth. The foot consists of only two toes, covered with imperfect nail-like hoofs, and destitute of the two supplementary toes. The soles of the feet are covered with a callous, horny integument upon which the animal walks. In the camels the toes are conjoined below by a callous pad, and the back is furnished with one or two fleshy humps. The Arabian Camel or Dromedary has only one hump. Camels live in dry situations, and they are specially adapted to this by possessing a number of large cells in the paunch, in which a great quantity of water can be stored up, thus enabling the animal to travel for days without drinking. They are of considerable use as transport animals. The Llama has no hump and separate toes, and takes the place of camels in South America, there being no camels in the New World.

Tragulina.

No teeth in the premaxillæ; the upper canines are well developed, especially in the males; narrow and pointed. Four complete toes on each foot. Ruminating, but the stomach with only three compartments instead of four as is also the case in camels (vide *supra*). No horns. Dental formula :—

$$i.\ \frac{0}{6};\ c.\ \frac{1-1}{1-1};\ pm.\ \frac{3-3}{3-3};\ m.\ \frac{3-3}{3-3}$$

FAMILY.—*Tragulidæ* (Chevrotians or Mouse Deer).

The *Tragulidæ* or *Chevrotians* are small animals with slender limbs and high hind quarters, resembling Musk Deer, but have no horns, while the canine teeth are developed in both jaws, and the upper canines of the males are tusk-like. They are found in India, inhabiting forests, the Indian Archipelago, and Africa. ***Tragulus meminna*** (fig. 380) is the Indian Chevrotian or Mouse Deer.

Pecora.

The typical Ruminants are distinguished by several well marked characters, of which the following are the most important :—

The animals are characterised by having a cloven foot consisting of a symmetrical pair of toes encased in hoofs, and looking as if produced by the cleavage of a single hoof.

Fig. 379.

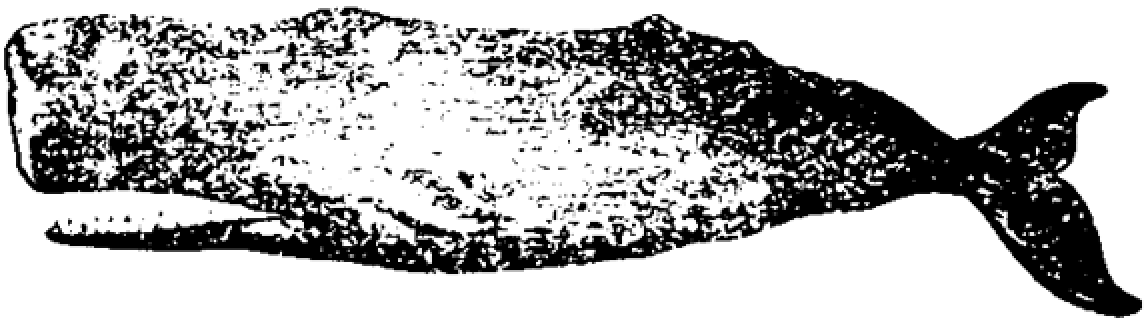


Fig. 380.

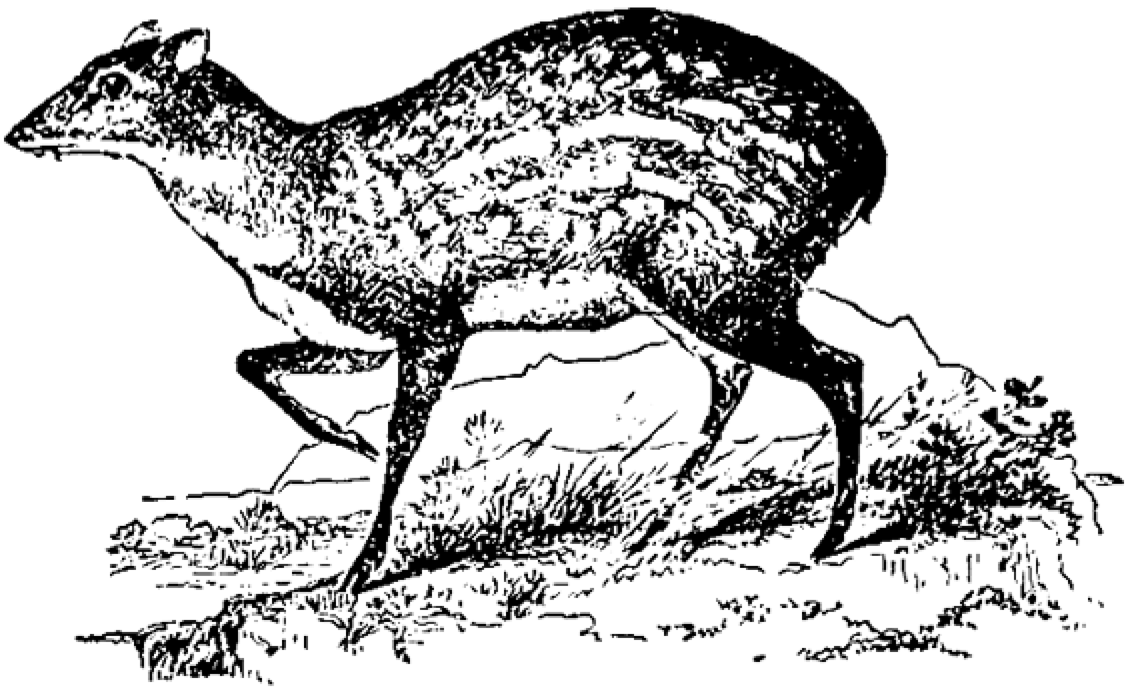
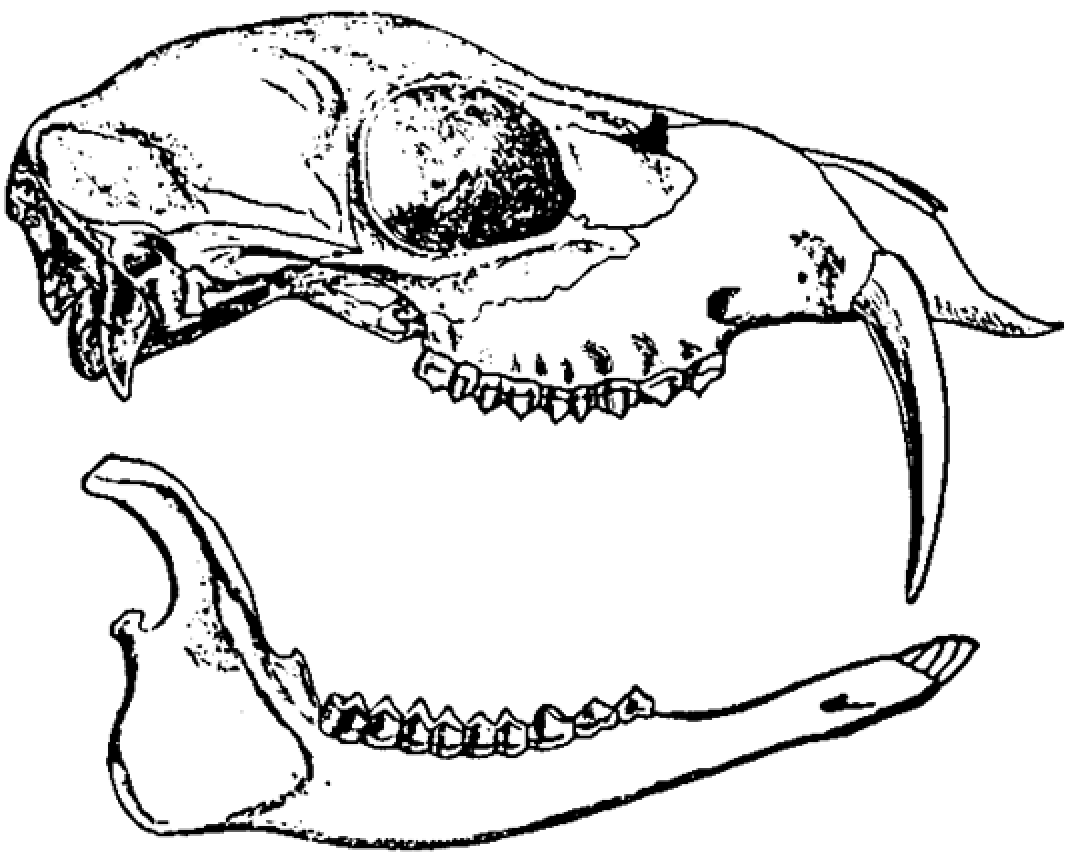


Fig. 381.



379. THE SPERM-WHALE (*Physeter macrocephalus*).
380. THE INDIAN CHEVROTAIN OR MOUSE-DEER (*Tragulus meminna*).
381. SKULL OF THE MUSK-DEER (*Moschus moschiferus*).

Fig. 382.

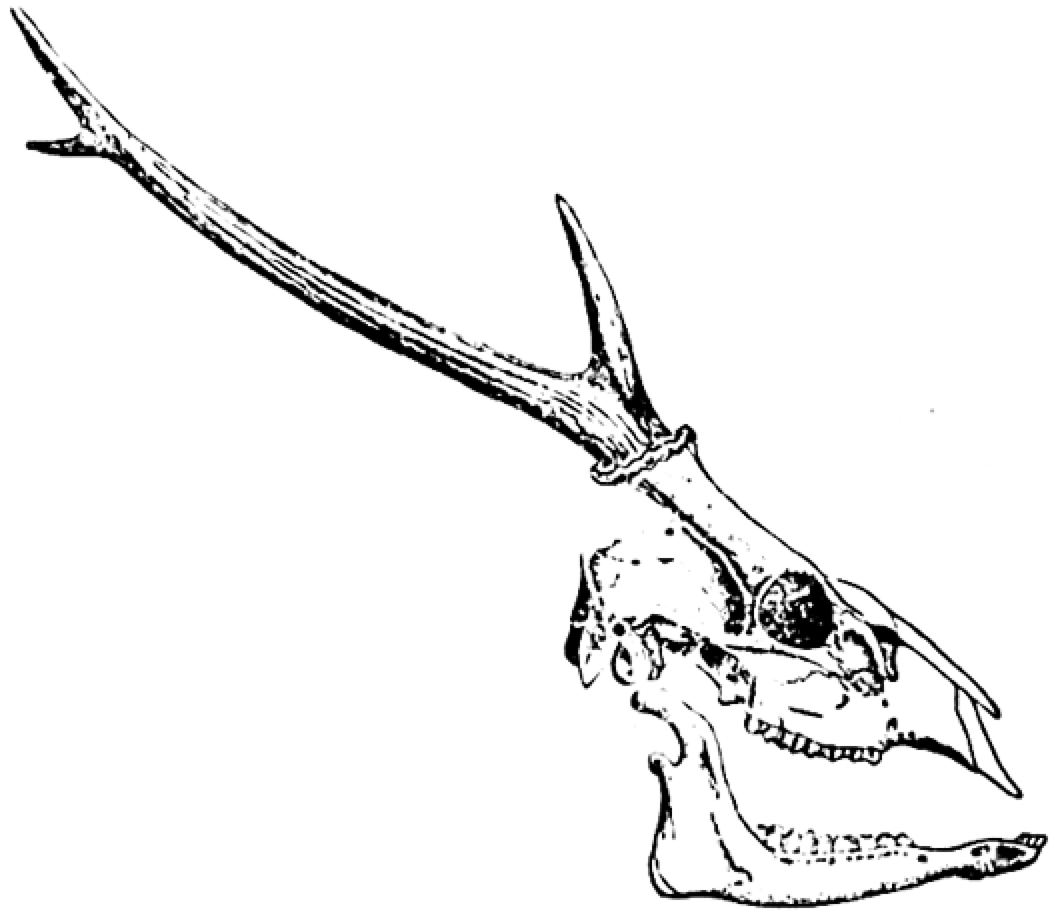
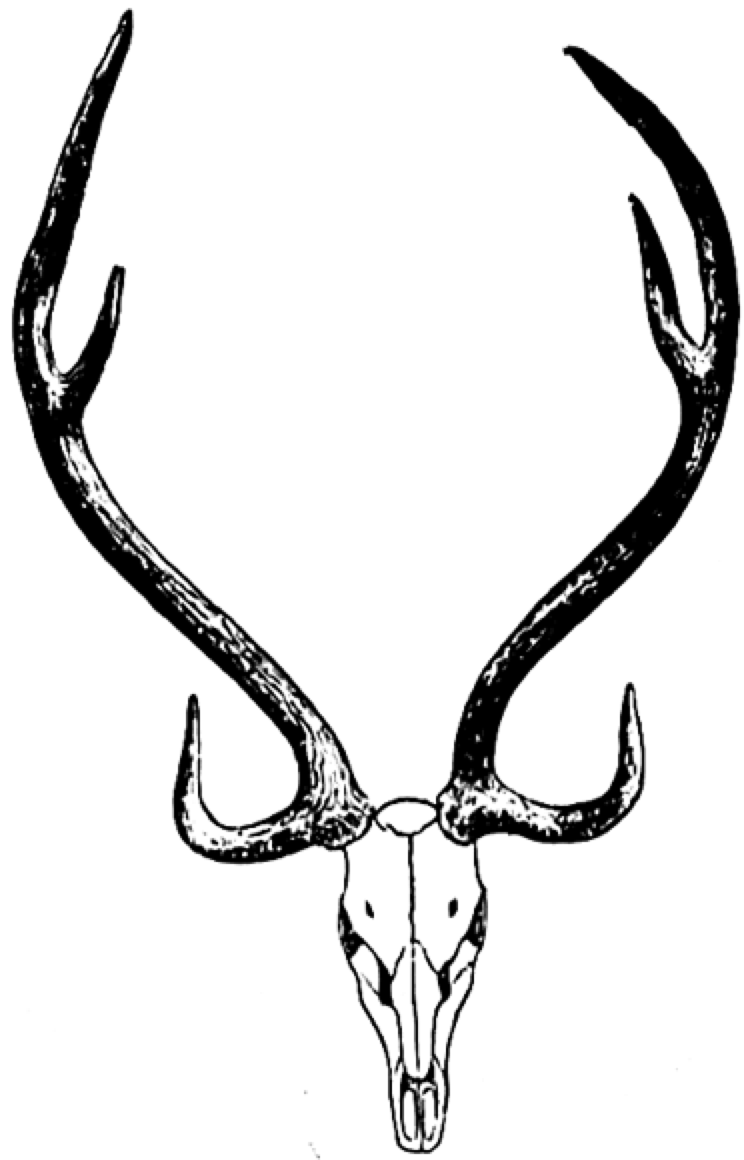


Fig. 383.



382. Skull and Horns of the Indian Hog-deer (*Cervus porcinus*).
383. Skull and Horns of the Spotted Deer (*Cervus axis*).

to face page 213.

The toes used to walk on are the third and fourth, but the second and fifth toes may be present in a rudimentary form on the back of the foot. They are never so far developed as to touch the ground when walking. As regards dentition, typically there should be no incisor or canine teeth in the upper jaw, but in the lower jaw there should be six incisors and two canines which are all similar in size and form and constitute a continuous and uninterrupted series of eight teeth placed in front of the lower jaw. There are six back teeth (premolars and molars) on each side of each jaw, and these have grinding surfaces, the enamel ridges of which form crescents. The typical dental formula of a Ruminant therefore is—

$$i.\ \frac{0-0}{3-3};\ c.\ \frac{0-0}{1-1};\ pm.\ \frac{3-3}{3-3};\ m.\ \frac{3-3}{3-3}=32$$

In the absence of incisor teeth in the upper jaw, the lower incisors bite against a pad of hardened gum. The camels differ in their dentition from the above formula. The stomach in the Ruminants is complex and is divided into several compartments, this being in accordance with their mode of eating. They all "ruminate" or "chew the cud," *i.e.*, they first swallow their food unmasticated, and then bring it up again after a longer or shorter period in order to chew it. This is effected as follows:—The gullet opens at a point between the first two compartments or stomachs, of which the largest lies to the left and is called the "paunch" while the smaller right cavity is called the "honey-comb bag" or reticulum. The paunch is the cavity into which the food is first received, and here it is moistened and allowed to soak for a time. After the food has lain sufficiently long in the paunch, it passes into the "honey-comb bag" from which it is again received into the mouth by a reversed action of the muscles of the gullet. After having been thoroughly chewed, and prepared for digestion, the food is now swallowed a second time. Now, however, instead of passing into the paunch the masticated food is conveyed into the third stomach which is known as the "many-plies" because its inner lining is thrown into a number of longitudinal folds, like the leaves of a book. The "many-plies" stomach opens by a wide aperture into the fourth and last stomach, the reed, which is a cavity of larger size which secretes the true digestive fluid (gastric juice), and it is here that the food is really digested. This fourth stomach terminates in the commencement of the intestine.

FAMILY.—*Cervidæ* (Deer).

The *Cervidæ* include the true Deer and the Musk Deer, and are characterised by the fact that the forehead with a few exceptions carries two solid bony antlers which are not hollow, and are usually branched. With the exception of the Reindeer these appendages are confined to the males and are deciduous, being as a rule produced annually before the rutting season and being shed and reproduced before the next season. In India, however, there are exceptions to this rule. They increase in size and, in typical stags, in the number of branches, or tines, every time they are reproduced, till in the old males they may attain an enormous size. New horns are at first clothed with a hairy skin (when they are said to be in velvet), which is subsequently rubbed off. The Hog-deer (*Cervus porcinus*, fig. 382), Chital (*Cervus axis*, fig. 383), Barking Deer (*Cervulus muntjac*, fig. 386), Sambar (*Cervus unicolor*, fig. 384), Swamp Deer or Barasingha (*Cervus duvauceli*, fig. 385), are all inhabitants of India andall belong to this family. In the Barking Deer the canines are large and the horns are carried on long bony stalks covered with hair. The Musk Deer (*Moschus moschiferus*, fig. 381) have enormously developed canines, but no incisors in the upper jaw and no horns.

Damage done by Deer.

The members of this family injure forests by browsing on the tops of seedlings and coppice shoots, by breaking down young growth and by wounding the bark of young trees by means of their horns. This latter may be either to get rid of the "velvet" of the new horn or by butting against the trees in the rutting season. Sambar are particularly harmful in this respect, and in every forest in India, where these animals are to be found, damage attributable to them will be easily discernible. Mr. Clifford stated that *Ficus elastica* plantations suffered from deer in Assam, and the same is the fact in the Chittagong Hill Tracts. A very strong and high fence is required to keep out these animals, and the method now adopted is to keep the plants in the nursery until they have reached a safe height. The author has noticed that young *Pinus longifolia* saplings in the inner Siwaliks appear to be almost invariably barked by Sambar.

Fig. 384.

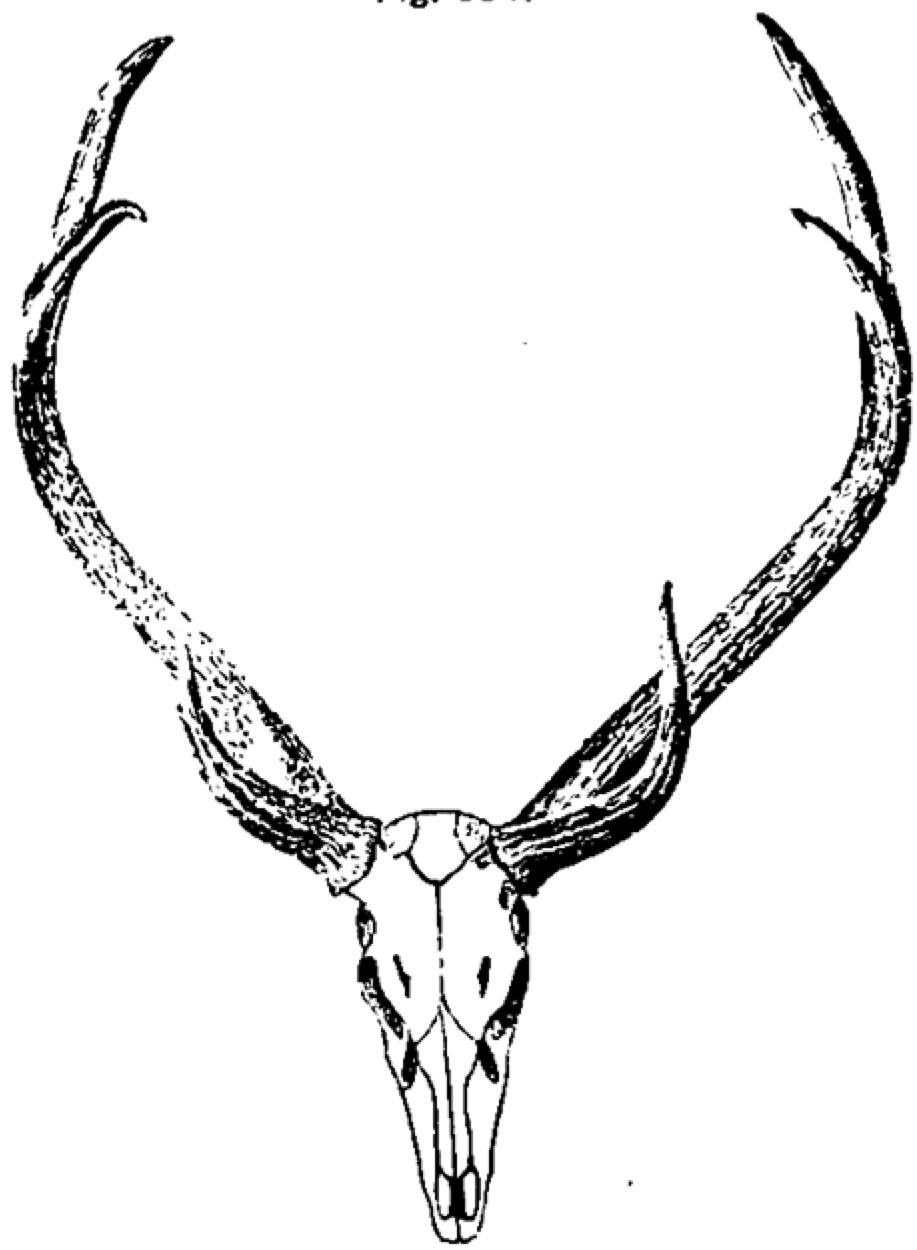
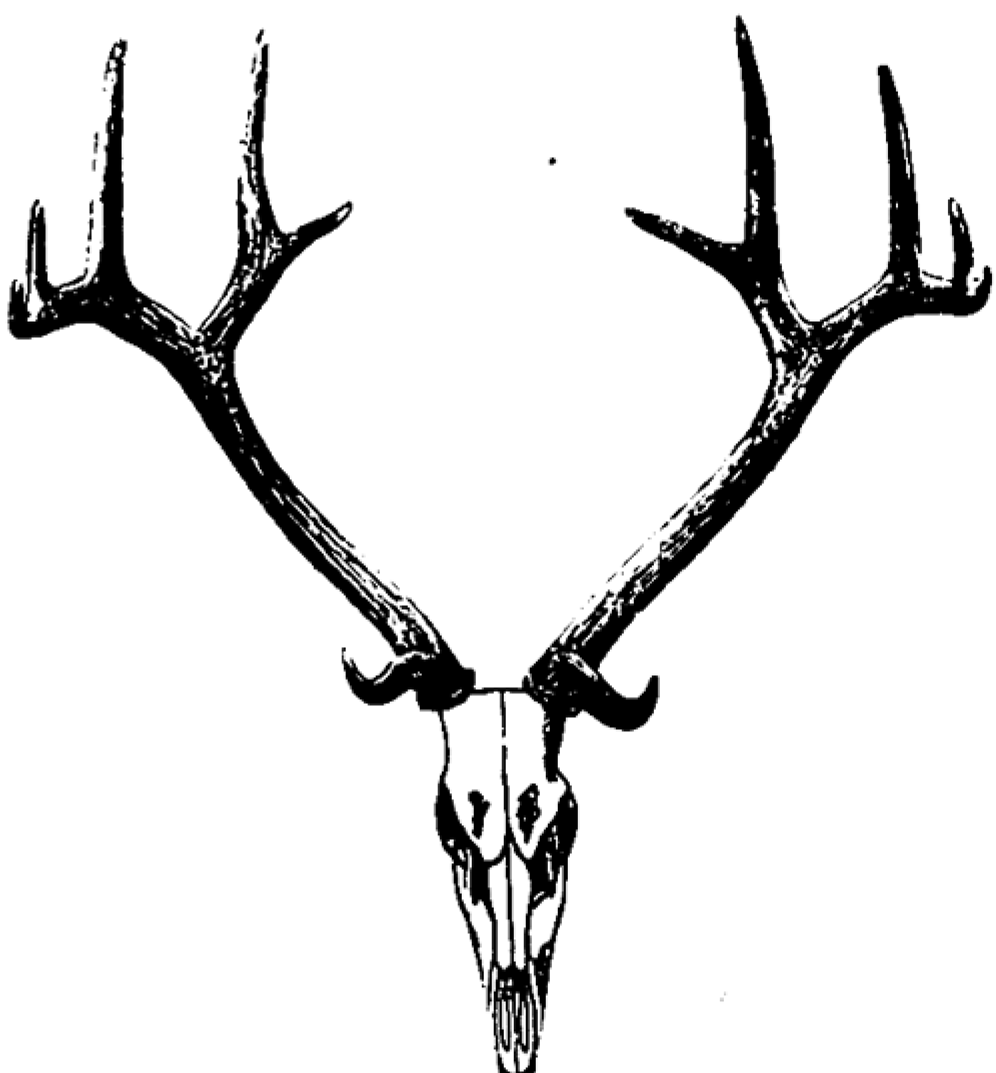


Fig. 385.



384. SKULL AND HORNS OF THE SAMBAR (*Cervus unicolor*).
385. SKULL AND HORNS OF THE BÁRASINGHA (*Cervus duvauceli*).

to face page 214.

Fig. 386.

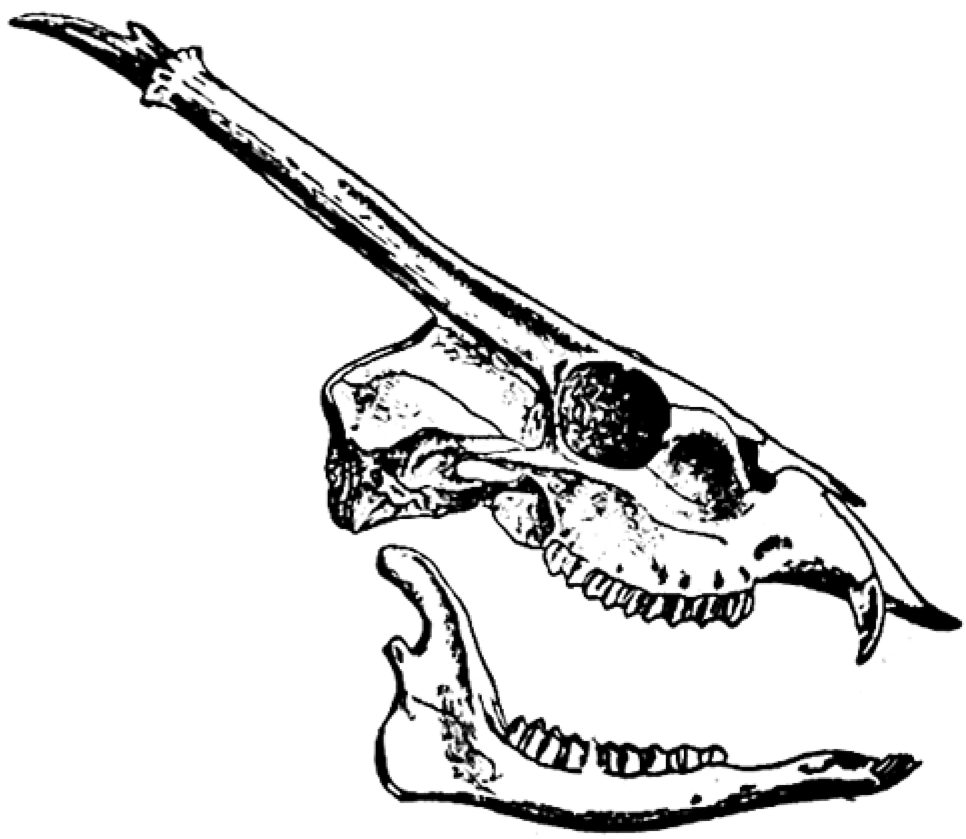
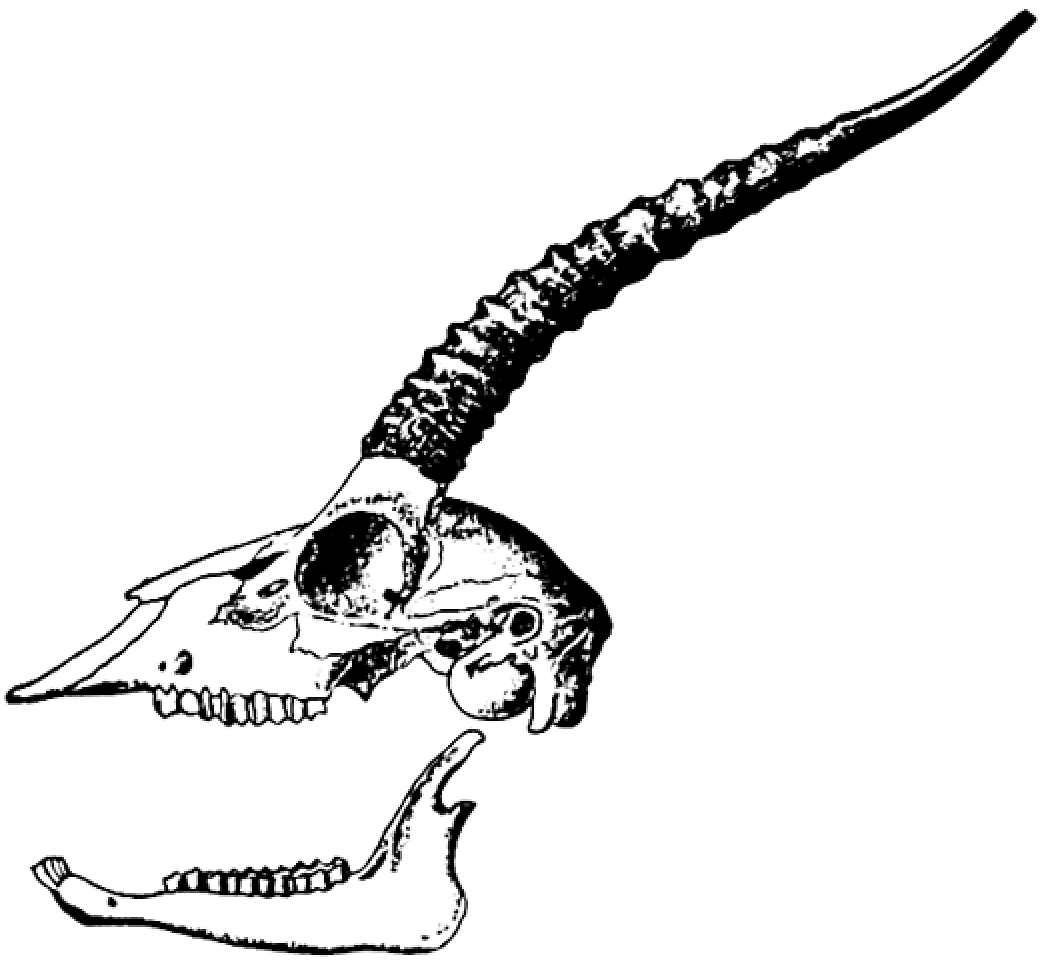


Fig. 387.



386. SKULL AND HORNS OF THE BARKING DEER (*Cervulus muntjao*).
387. SKULL AND HORNS OF THE INDIAN GAZELLE OR CHINKARA (*Gazella bennetti*).

to face page 215.

FAMILY.—*Giraffidæ* (Giraffes).

The Giraffes (*Giraffidæ*) are exclusively confined to Africa, and there is only one living species. Both sexes have from two to five horns, which are persistent and covered with a hairy skin. The neck is extremely long and the fore-legs longer than the hind ones.

FAMILY.—*Bovidæ*.

The *Cavicornia* or Hollow-horned Ruminants comprise the Oxen, Sheep, Goats, and Antelopes, and are characterised by having horns which may be present in one or both sexes, and consist of a horny sheath surrounding a central bony axis or "horncore." The horns are persistent and are not periodically shed; there is usually only one pair, though there may be two. They have the typical ruminant dentition, and they include a number of animals which are of the highest utility to man.

The Antelopes are represented in India by four species—the Indian Antelope or Black Buck, the Gazelle or Chinkara (fig. 387), the Blue Bull or Nilgai, and the four-horned Antelope, but they are chiefly African. They closely resemble true deer, but can be distinguished by the possession of hollow horns, instead of solid antlers.

The Sheep and Goats are closely allied to one another, there being several domestic varieties. All the sheep are natives of the Old World, with the exception of one (*Ovis montana*) in the Rocky Mountains. The Indian representatives of this family are the Goral (*Cemas goral*), Serow (*Nemorhædus bubalinus*, fig. 388), Ibex, Tahr (*Hemitragus jemlaicus*, fig 389), Markhor (*Capra falconeri*, fig. 390), Bharal (*Ovis nahura*, fig. 391), Urial (*Ovis vignei*, fig. 392) and the Great Pamir Sheep (*Ovis poli*, fig. 393).

The genus *Bos* includes that most important animal the domestic ox (*Bos taurus*) with its varieties and the humped ox, *B. indicus*. The true buffaloes are natives of Asia and Africa. The Mithan (*Bos frontalis*, fig. 394) and the Gaur or Indian Bison (*Bos gaurus*, fig 395) and the Yak belong here. The American Buffalo (*Bison americanus*) is a true Bison closely allied to the European Bison, and has an enormous head and shaggy mane.

Damage done by other animals.

The damage done by sheep and goats and cattle in the forest is usually of a serious nature, as young seedlings, coppice shoots, and even saplings are grazed down or broken down by them. Although owing to their greater size buffalo and cattle probably commit more havoc by breaking down plants, it is unquestionable that the goat is by far the greatest evil. Everything is food to him, and his method of feeding is most wasteful, add to which his powers of climbing enable him to commit greater damage. Sheep, from their habit of keeping together in droves, are dangerous on hill-sides and steep, shaly areas owing to the constant treading in each other's tracks, and the destruction thereby caused.

SUB-ORDER.—PERISSODACTYLA.

Includes the tapirs, horses, and rhinoceroses. The third or middle digit is much more developed than the others, its two sides being similar. The number of digits on each foot is, as a rule, odd and, except in tapirs which have four toes on each fore-foot, is one or three. The premolar and molar teeth are similar and form a continuous series. The stomach is simple. Fig. 397 shows the bones of the manus of a tapir, horse, and rhinoceros.

FAMILY.—*Tapiridæ* (Tapirs).

The Tapirs (*Tapiridæ*) have four toes to each of the fore-legs (fig. 396 c), but only three toes on the hind-legs, so that they are really odd-toed. No horns are present. The nose forms a short movable proboscis used in stripping off the leaves of trees. They are large, clumsy, pig-like animals, which inhabit South America, Sumatra, Borneo, and the Malay Peninsula with Tenasserim.

FAMILY.—*Equidæ*.

The Horse and its allies (*Equidæ*) comprise the Horses, Asses, Zebras, and Quaggas. The foot carries only a single toe (the third toe), which is furnished with a broad hoof (fig. 396 a). Upon the end of this toe the animal walks. The second and fourth toes are present in a rudimentary form as little bony splints (the so-called "splint-bones"), hidden under the skin. There is a continuous series of incisor teeth

Fig. 388.

Fig. 389.

388. SKULL AND HORNS OF THE SEROW OR HIMALAYAN GOAT-ANTELOPE (*Nemorhædus bubalinus.*)

389. THE TAHR (*Himitragus jemlaicus*).

to face page 216

Fig. 390

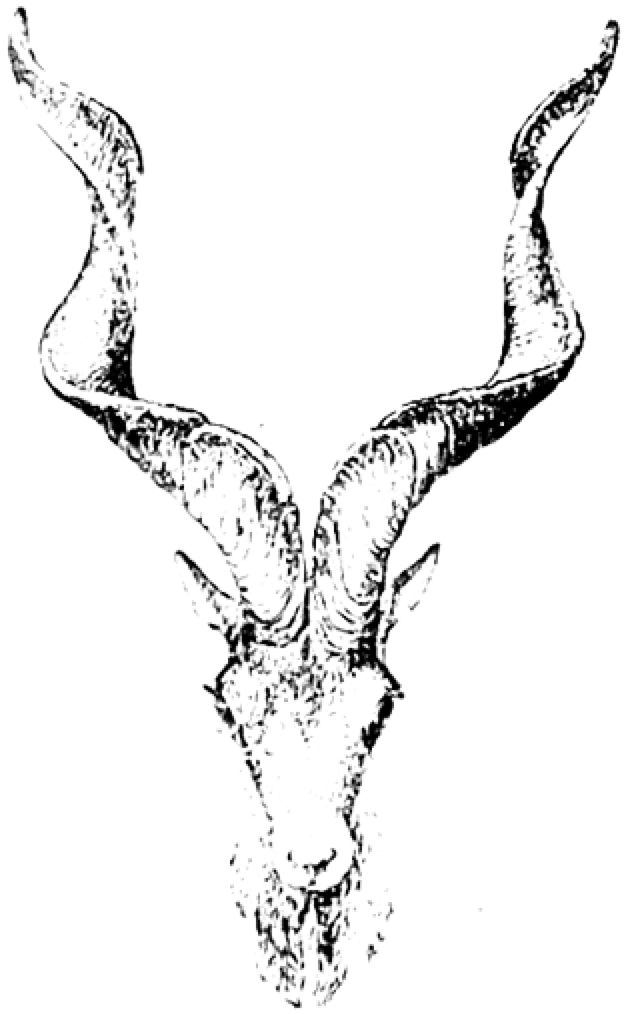


Fig. 391.

390. THE MARKHOR (*Capra falconeri*) PIR PANJAL VAR.
391. THE BHARAL OR BLUE WILD SHEEP (*Ovis nahura*).

to face page 417.

in both jaws, and in the males canines are present. The dental formula is—

$$i.\ \frac{3-3}{3-3};\ c.\ \frac{1-1}{1-1}\ \text{(or none)};\ pm.\ \frac{3-3}{3-3};\ m.\ \frac{3-3}{3-3} = 40$$

All the domestic varieties of horses appear to be descended from the single species *Equus caballus*, which seems to have been primitively a native of Central Asia, in which country another species of horse has recently been discovered.

The genus Asinus includes the Asses, Zebras, and Quaggas. The wild asses are natives of Asia and North-Eastern Africa. The Zebras and Quaggas are exclusively African and are distinguished by their beautifully striped body. Lately another African animal of this family, known as the Okapi, has been discovered.

FAMILY.—*Rhinocerotidæ* (Rhinoceros).

Three digits on each foot; one or two horns on the nose. The Rhinoceroses are extremely large animals, having very thick and nearly hairless skin, usually hanging in thick folds. The feet are furnished with three toes each, all encased in hoofs (fig. 396 b). The nose is furnished with one or two horns. If two horns are present, they are not paired, but one is placed behind the other, the hinder one being much the shortest. The Sumatran rhinoceros has a pair of horns, but they are longitudinally arranged. The various species of Rhinoceroses are found in India, Java, Sumatra, and Africa, feeding chiefly on grass and the foliage of trees. They are sometimes found in marshy ground, but some of them inhabit hilly country. The Indian species (*R. unicornis*, fig. 397) is now practically confined to the forests of Nepal, North-East Bengal, east of the Tista river, and Assam.

SUBUNGULATA.

By far the greater number of the Subungulata are extinct. The feet often have five functional digits and may be plantigrade.

SUB-ORDER.—HYRACOIDEA.

FAMILY.—*Hyracidæ*.

This sub-order is unimportant. It comprises the genus *Hyrax*. The animals are small and gregarious, mostly living in holes in rocks.

They resemble in many ways the Rhinoceros, especially in the form of their molar teeth. The incisor teeth of the upper jaw are long and curved with sharp cutting edges, and they grow from a persistent pulp, thus resembling the teeth of the Rodents (Rabbit and Beaver, etc.). The so-called Badger of South Africa is a well-known species of Hyrax.

SUB-ORDER.—PROBOSCIDEA.

FAMILY—*Elephantidæ* (Elephants).

The only living animals belonging to this sub-order are the Indian and African elephants. The name of the order is derived from the fact that the nose is prolonged into a long, cylindrical trunk or proboscis, which is very muscular and terminates in a finger-shaped lobe, below which are placed the apertures of the nostrils. The proboscis is the sole organ of prehension of the animal and is employed to take up water, and also to introduce into the mouth the vegetable substances upon which the elephant feeds. The elephant in fact is unable to apply the mouth directly to the ground, either for feeding or drinking, owing to the peculiar form of the incisor teeth. The upper incisors are two in number and often constitute long tusks which grow throughout the whole life of the animal. and in old individuals may reach 6—7 feet long. There are no lower incisor teeth, aud canine teeth are absent in both lower and upper jaws. Each jaw, however, usually has a pair of exceedingly large molar teeth which are transversely ridged and are used in chewing the food. Only one or two premolars and molars are in use at a time, and as they are worn out and shed they are replaced by the next teeth behind them. The form of the animal is very massive, and the skin is thick and covered with scattered hair.

The feet have five toes each, but all the toes do not carry hoofs, and the animal walks upon a thick pad of horny skin, which forms the sole of each foot. The Indian elephant inhabits India and the Indian Archipelago, and has generally five hoofs to the fore-feet but only four to the hind-feet. The Ceylon elephant is a mere variety. The males alone possess well-developed tusks, but tuskless males are of common occurrence, especially in Ceylon, and are known in India as "Makna." The African elephant is very similar to the Indian one. Both sexes of the former, however, also possess tusks, those

Fig. 392.

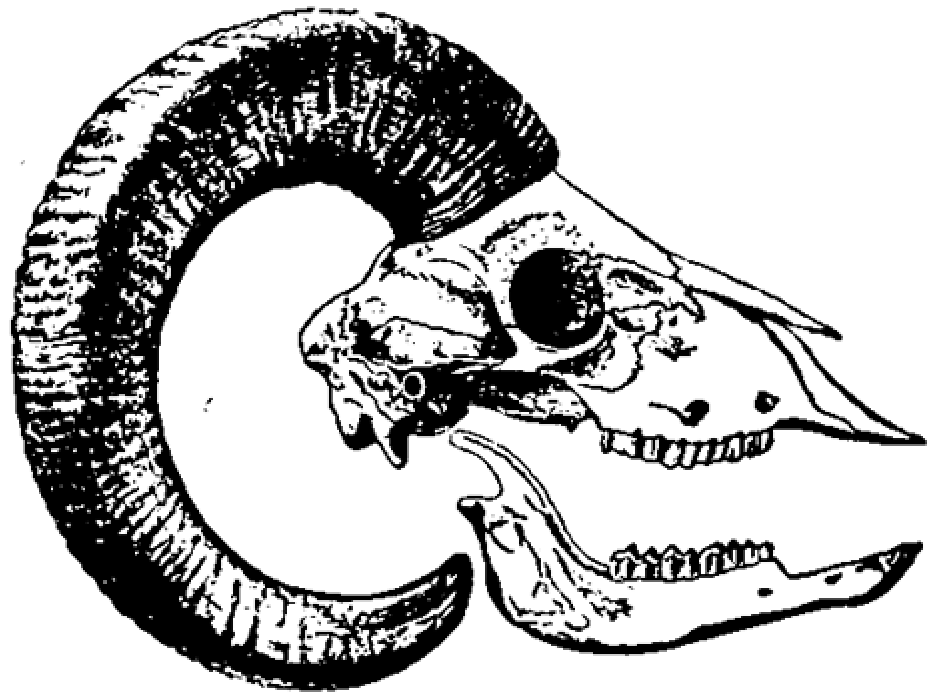


Fig. 393.

Fig. 394.

Fig. 395.

392. Skull and Horns of the Urial (*Ovis vignei*), Salt Range var.
393. Skull and Horns of the Great Pamir Sheep (*Ovis poli*).
394. Skull and Horns of the Gayal or Mithan (*Bos frontalis*).
395. Skull and Horns of the Gaur (*Bos gaurus*) (Indian Bison).

Fig. 396.

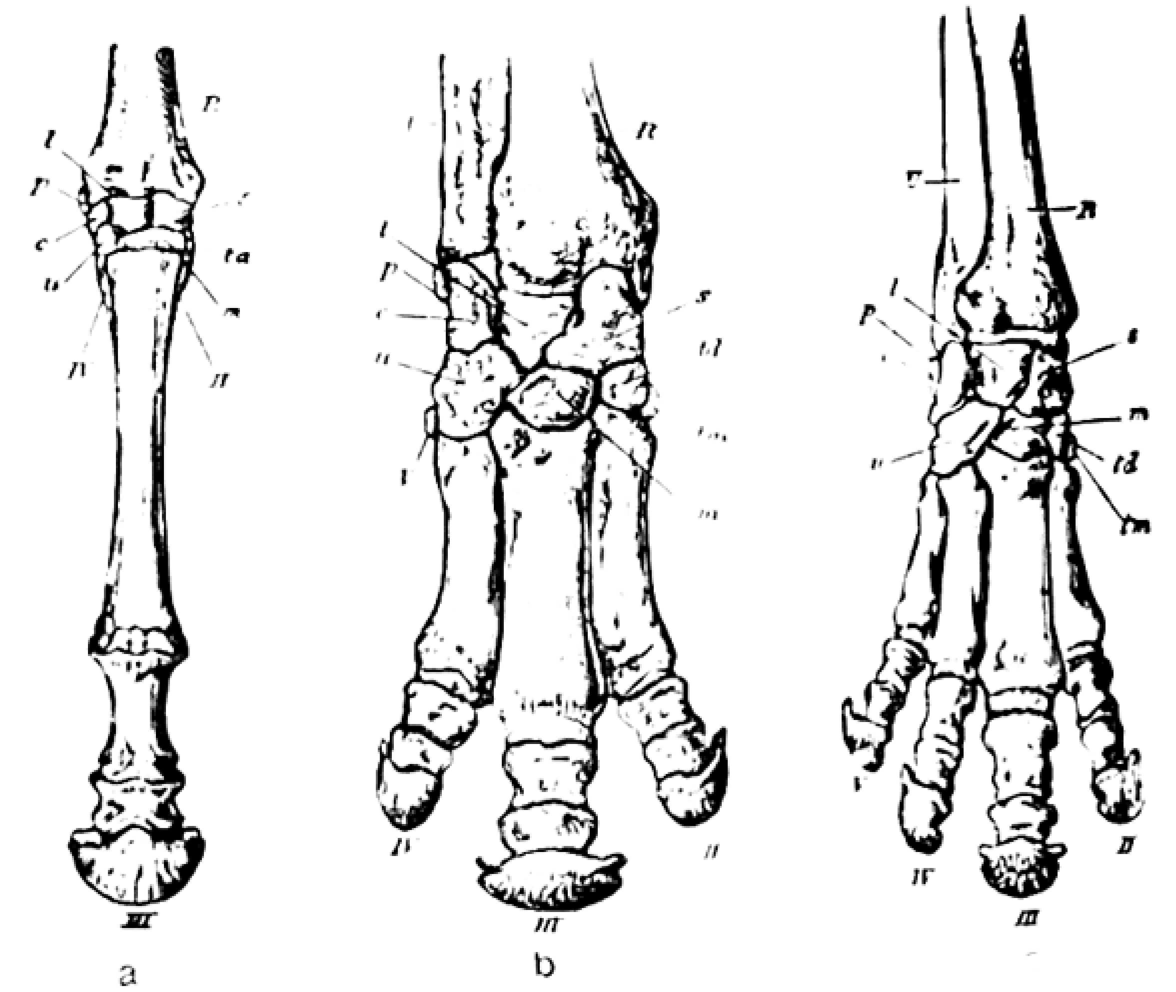
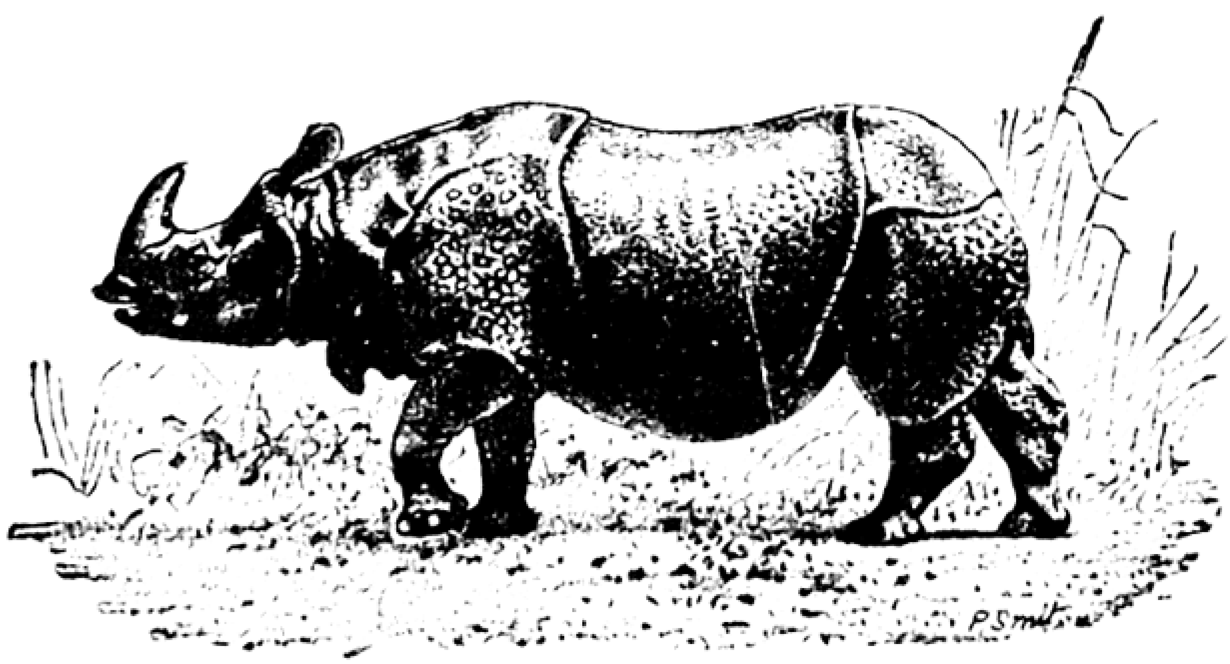


Fig. 397.



396. Bones of the Manus of :—*a*, Horse (*Equus caballus*) ; *b*, *Rhinoceros sumatrensis* ; *c*, Tapir (*Tapirus indicus*) ; II, III, IV, V, second, third, fourth, and fifth digits ; U, ulna ; R, radius.

397. The great one-horned Rhinoceros (*Rhinoceros unicorins*).

of the males being largest. There are many extinct forms of elephants, amongst which the best known is the Mammoth which undoubtedly existed in Europe within the human period.

Elephants commit damage in the forest by breaking down young trees or stripping off their bark or that of the branches.

ORDER 7.—RODENTIA.

This order comprises a number of small animals, characterised by the absence of canine teeth, and the possession of two long curved incisor teeth in both jaws, which are separated by a wide interval from the molars. There are seldom more than two incisors in the upper jaw (sometimes four), but there are never more than two in the lower jaw. The molar teeth are few in number (rarely more than four on each side of each jaw). The feet are usually furnished with five toes each. The most characteristic point about the rodents is to be found in the structure of the incisor teeth, which are adapted for continuous gnawing. They grow from persistent pulps, and consequently continue growing as long as the animal lives. They are large, long, and curved, and are covered in front with a layer of hard enamel, so that the softer parts of the tooth are placed behind. The result of this is that as the tooth is used in gnawing, the softer parts wear away more rapidly than the hard enamel in front and thus the crown of the tooth acquires by use a chisel shape, bevelled away behind, and the enamel forms a persistent cutting edge. The rodents are almost all of small size and are very prolific. They live chiefly on vegetable matters, especially on the harder parts of plants, such as the bark and roots, and they do harm in nurseries and plantations by gnawing away the roots and bark of seedlings and killing them. Many build very elaborate nests, and most of them hibernate during the cold months. They are very generally distributed over the world. The most important families are :—

(1) *Leporidæ* comprising the hares and rabbits, several species of the former of which are present in India. They feed on vegetation; hares are a nuisance in nurseries, to crops, gardens, etc.

Fig. 398 shows the skull of an Indian species known as *Lepus nigricollis*, the black-naped hare of Southern

India. *L. ruficandatus* is the common hare of Northern India.

(2) *Hystricidæ* comprising the Porcupines, which are characterised by having the body covered with longer or shorter spines or quills mixed with bristly hairs. They mostly live in burrows and are like rabbits in their habits. A few American species have prehensile tails and live in trees. The common Indian one, *Hystrix leucura*, of which fig. 400 shows the skull, does damage to young plants and to old trees by gnawing off the bark. Many of the Khair trees in the Siwalik forests have been badly attacked in this way. Fig. 399 depicts *Atherura macrura*, the Asiatic brush-tailed porcupine, an inhabitant of Assam and Burma, etc

(3) *Castoridæ* or Beavers, which have webbed feet and a scaly tail and a fur which is of considerable value. They inhabit North America and Europe, living in water and damming up streams.

(4) The bamboo rats (Family *Spalacidæ*), of which fig. 401 shows *Rhizomys sumatrensis*, live in burrows under the roots of trees and feed upon roots, bamboos, grass, etc.

(5) *Muridæ* comprising the Rats, Mice, Lemmings, Voles, etc. The mice and rats are well known and often give trouble to the forester by gnawing off the roots of seedlings in nurseries and eating stored seeds, in this way doing considerable damage. They are also common household pests to man. *Gerbillus indicus* (fig. 403) is a rat which lives in holes and galleries in waste lands and often attacks grain and other seeds in a most serious manner committing very heavy depredations. *Mus rattus* is the common Indian rat, whilst *Mus musculus* is the ordinary house mouse, and *M. buduga*, the common mouse of the fields. *Microtus blythi* (fig. 402) is a vole of the Himalayas.

(6) *Sciuridæ* comprising the Squirrels, Flying Squirrels, and Marmots. The flying squirrels do not really fly but take

Fig. 398.

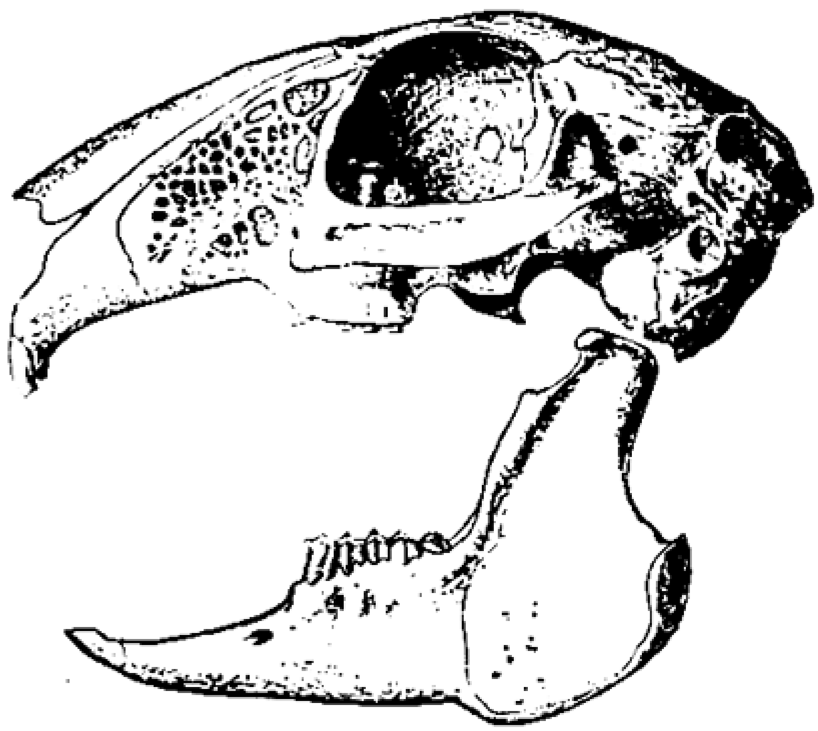
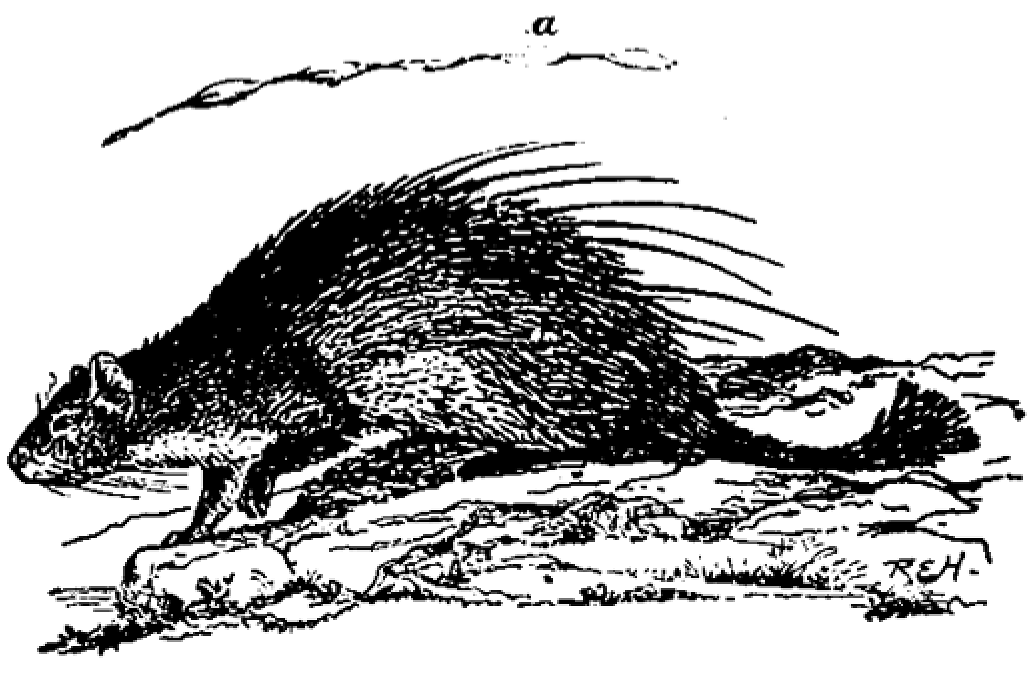


Fig. 399.



398. Skull of the Black-Naped Hare (*Lepus nigricollis*).

399. The Asiatic Brush-tailed Porcupine (*Atherura macrura*); *a*, one of the bristles at the end of the tail.

Fig. 400.

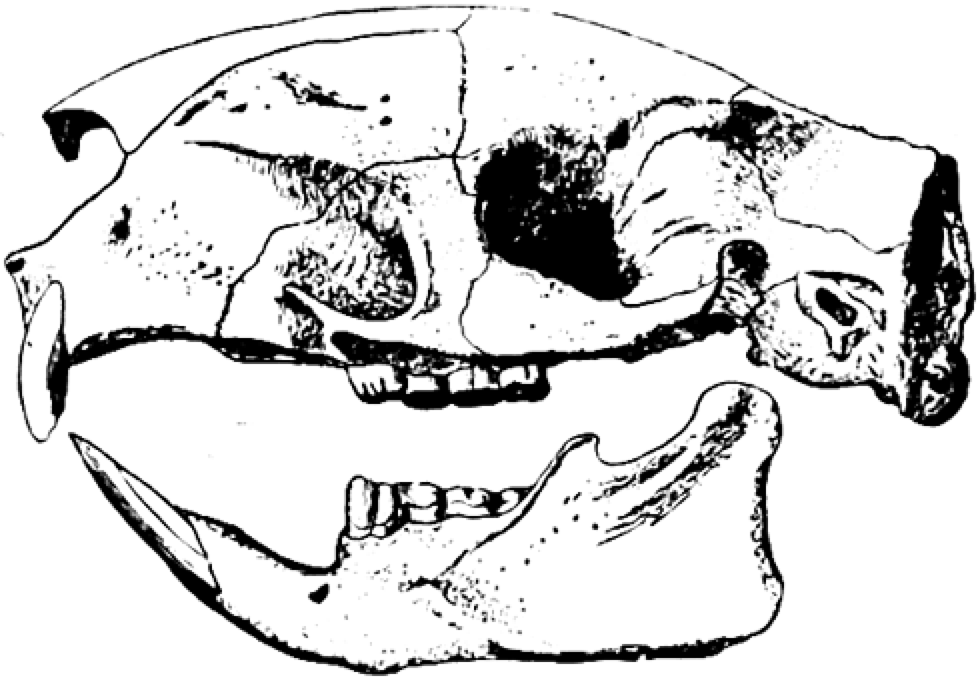


Fig. 401.

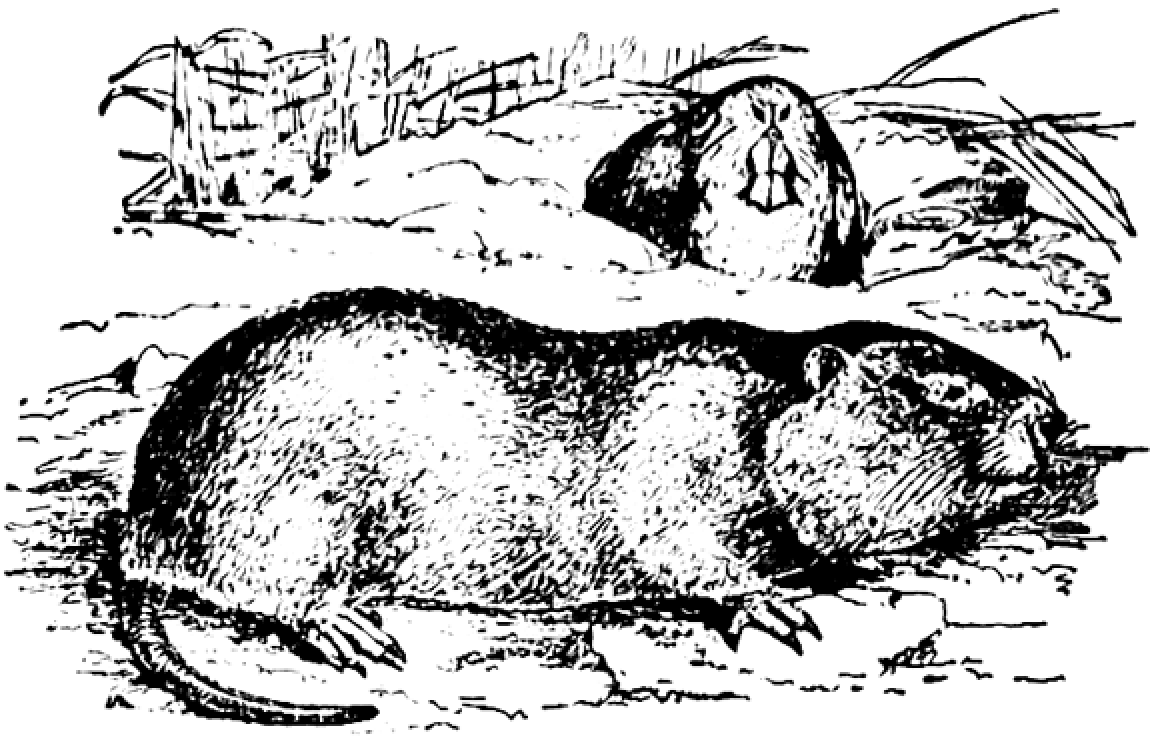
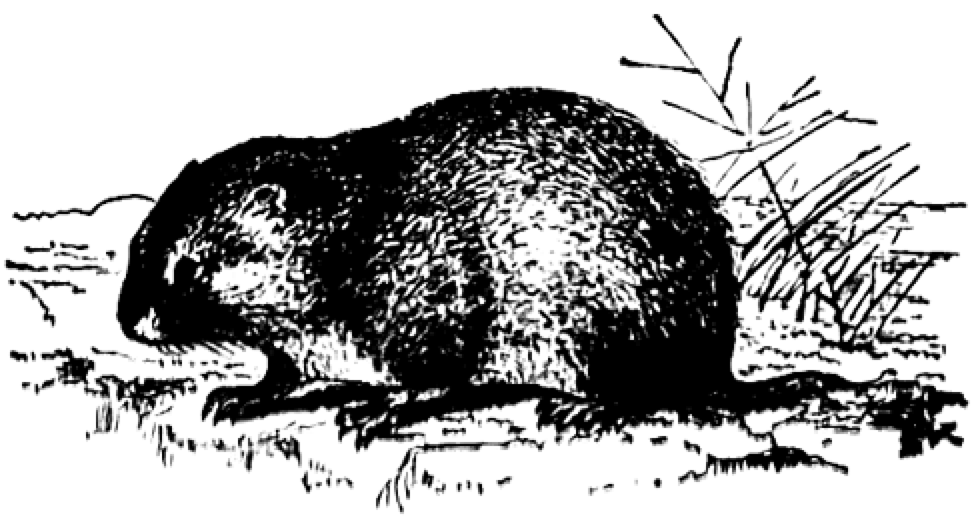


Fig. 402.



400. SKULL OF THE INDIAN PORCUPINE (*Hystrix leucura*).
401. THE LARGE BAMBOO-RAT (*Rhizomys sumatrensis*).
402. BLYTH'S VOLE (*Microtus blythi*).

long leaps from tree to tree by means of laterally extended folds of skin. The squirrels live in trees and cause damage by feeding on the seeds and fruits of trees, which they often store up in considerable quantities. The common large brown flying squirrel (*Pteromys oral*) depicted in fig. 405 is an inhabitant of tree forests living in holes in the daytime. *Sciurus macclellandi* is the common striped squirrel of the Himalayas.

The marmots live in holes in the ground.

Fig. 404 shows the red Marmot, *Arctomys candatus*, of the North-Western Himalayas.

The Guinea-pigs (*Cavindæ*) are not Rodentia.

ORDER 8.—CARNIVORA (Beasts of Prey).

This order comprises the Beasts of Prey, including the Lions, Tigers, Wolves, Dogs, Cats, Civets, Mungooses, Stoats, Weasels, Hyænas, Seals, Walruses, Bears, etc. These animals are distinguished by possessing two sets of teeth, which are simply enamelled, and are always of three kinds: incisors, canines, and molars, differing from one another in size and shape. The incisor teeth are generally six in each jaw; the canines are always two in each jaw, and are longer than the other teeth. The premolars and molars are mostly cutting teeth, furnished with sharp uneven edges, but one or more of the hinder teeth have tuberculate crowns. Fig. 405 shows the upper sectorial teeth of *Felis*, *Canis*, and *Ursus*. The dentition differs considerably in different members of the order, the following being the dental formula of the cats (*Felidæ*) which are the most typical examples of the carnivora:—

$$i.\ \frac{3-3}{3-3};\ c.\ \frac{1-1}{1-1}\ pm.\ \frac{3-3}{2-2};\ m.\ \frac{1-1}{1-1}=30$$

In the *Felidæ* and other typical carnivora the last premolar in the upper jaw and the first molar in the lower jaw are specially developed and are known as the "carnassial" teeth, having a sharp cutting edge; whereas in other cases the corresponding teeth are blunt and tuberculated. As a general rule, the shorter the jaw, and the fewer the premolars and molars, the more carnivorous is the animal. The jaws are articulated so that the movements are vertical and not horizontal;

and the sharp-edged back-teeth are thus enabled to act like the blades of a pair of scissors. A skull of the clouded leopard (*Felis nebulosa*) exhibits this dentition (fig. 407). In addition to having this strictly flesh-eating dentition, the carnivora also have the feet provided with strong curved claws; and the collar-bones are either quite rudimentary, or are altogether absent. The order is divided into two sub-orders, named Pinnipedia and Fissipedia.

(1) PINNIPEDIA.

The whole external form of the animals is modified for an aquatic life, the hind feet being converted into swimming paddles. The teeth of the molar series, both premolars and molars, are similar to each other in size and form.

This sub-order includes the seals and lruses, both of whom are inhabitants of cold climates and are not found in India. The walruses can be distinguished from the seals by their enormously-developed upper canines which form two pointed tusks.

(2) FISSIPEDIA OR CARNIVORA VERA.

These animals are fitted for a terrestrial or partially terrestrial life, the feet not being formed into web swimming paddles. The animals walk either on the soles (bear), palms (otter), or toes (cat) of the foot. The pupil is circular in most of the large carnivora. The teeth of the molar series in each jaw are dissimilar in size and form, there being always one tooth on each side, above and below, that is especially modified, and is called the "carnassial" or flesh-tooth.

The sub-order is divided into three groups, named Æluroidea, Cynoidea, and Arctoidea, from the Greek names of the cat, dog, and bear, respectively; each of these animals being typical of a particular section of the carnivora.

ÆLUROIDEA.

FAMILY.—*Felidæ*.

The *Felidæ* comprise the Lions, Tigers, Leopards, Panthers Lynxes, Cats, etc. These animals are the most highly carnivorous and therefore the most typical of the carnivora. In all of them the animal walks upon the tips of the toes, and the soles of the

Fig. 403.

Fig. 404.

403. THE INDIAN ANTELOPE RAT (*Gerbillus indicus*).
404. THE RED OR LONG-TAILED MARMOT (*Arctomys caudatus*).

to face page 222.

Fig. 405.

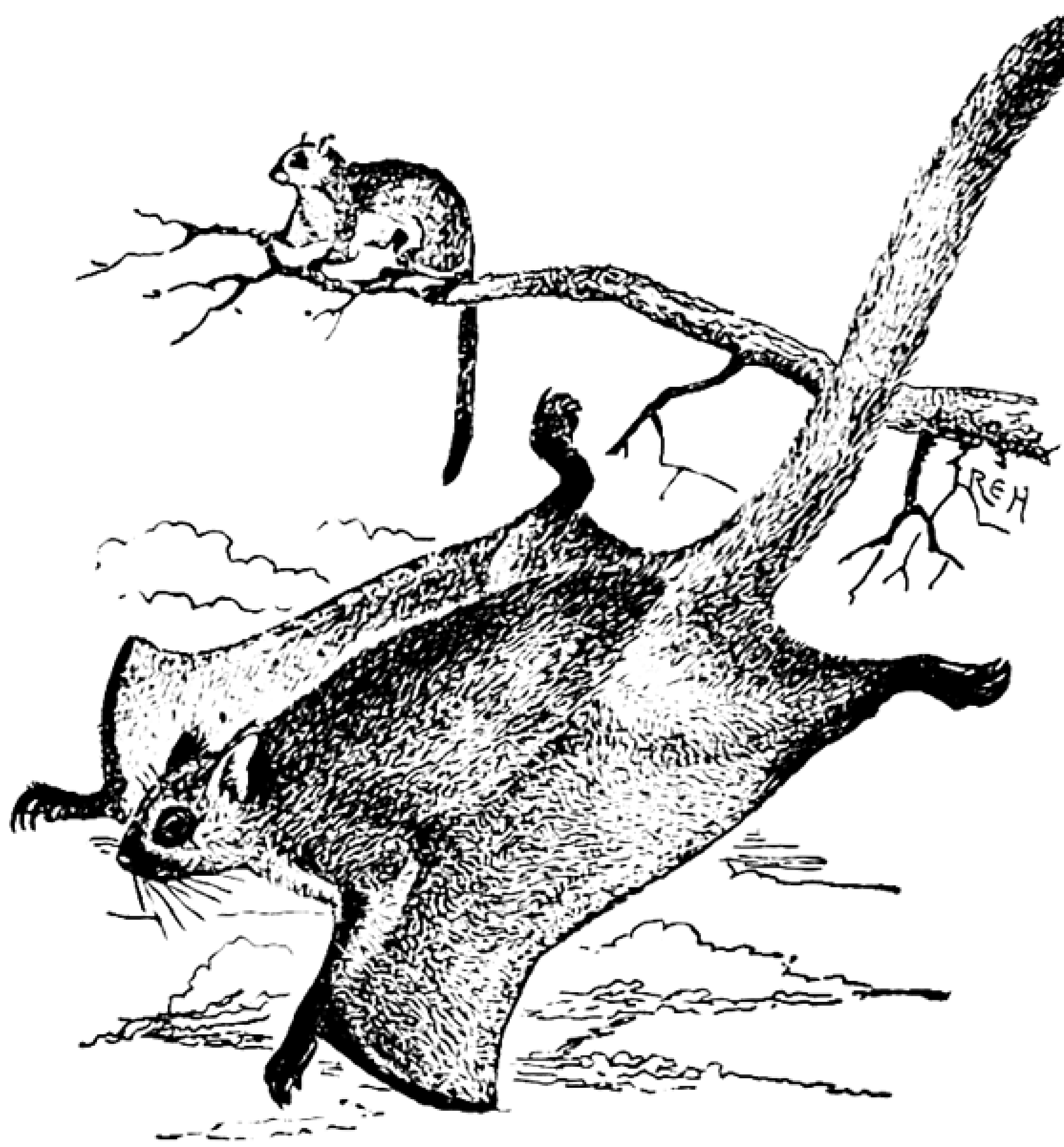
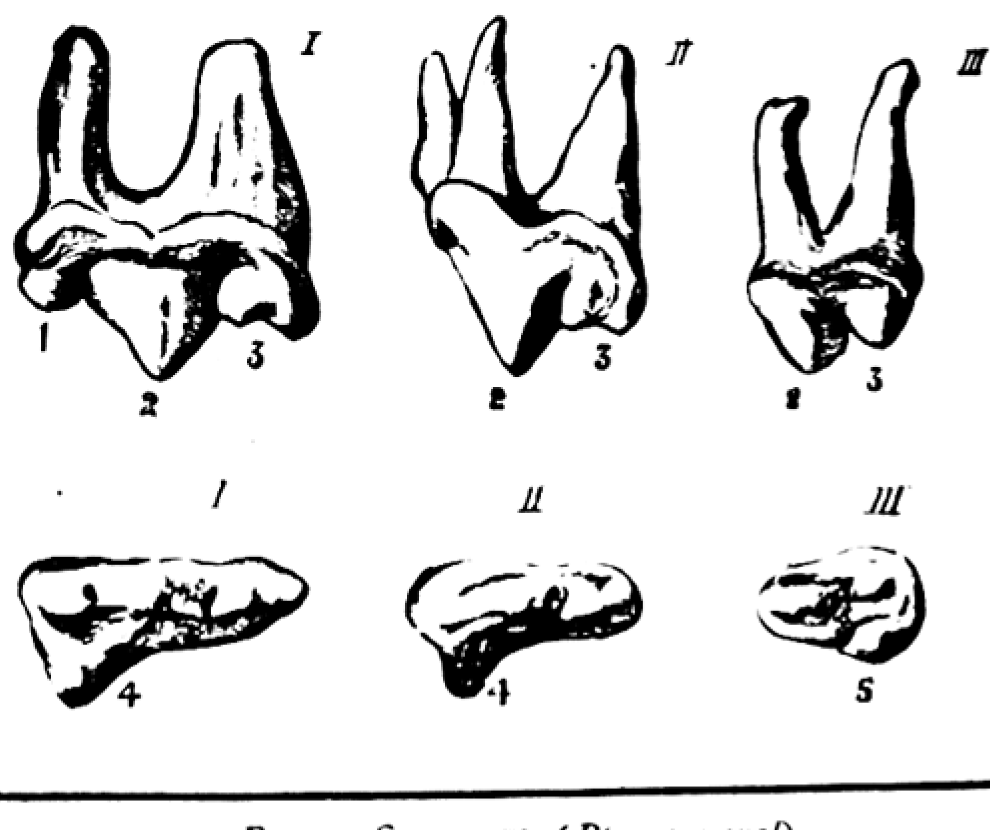


Fig. 406.



405. THE LARGE BROWN FLYING-SQUIRREL (*Pteromys oral*).

406. UPPER SECTORIAL TEETH OF I. *Felis*; II. *Canis*; III. Ursus.—1, anterior; 2, middle; 3, posterior cusp of blade; 4, inner lobe supported on distinct roots: 5, inner lobe posterior in position, and without distinct root, characteristic of the *Ursidæ*.

to face page 223.

feet are hairy. The jaws are short, the head rounded, with a short muzzle. The molars and premolars are fewer in number than in any of the other carnivora and hence the shortness of the jaws: and they are all furnished with cutting edges, except the single molar in the upper jaw, which is tuberculate. The legs are of nearly equal length and the hind-feet have only four toes, whilst the fore-feet have five toes each. All the toes are furnished with strong, curved retractile claws, which, when not in use, are withdrawn into sheaths. The tongue is rough. The animals are all very muscular and all seize the prey by suddenly springing upon it. The lions are confined to the Old World, inhabiting Southern Asia and Africa. A few still exist in the Gir forest in Rajputana. The tiger (*Felis tigris*) is found in Asia only, whilst the leopards (*F. pardus*, etc.) are found in both the Old and New Worlds, as also are the Lynxes which have tufted ears. The cats are numerous in India. *Felis bengalensis* (fig. 408) is a cat common in the hilly regions of the country.

FAMILY.—*Viverridæ.*

This family includes the civets, mongooses, etc., which are moderate-sized animals with sharp muzzles and long tails, and body either striped or spotted. The canines are long, sharp, and pointed, the claws being semi-retractile.

The genera *Viverra* and *Viverricula* comprise the true Civet-cats from which the substance known as civet, largely used as a perfume, is obtained. It is secreted in special glands. Two other glands near the anus have a very different secretion, the odour of which is extremely offensive. Fig. 409 shows *Viverra sibetha*, the large Indian Civet-cat. The common Indian mongoose is well known.

FAMILY.—*Protelidæ.*

The *Protelidæ* have five toes on the fore- and four toes on the hind-feet. They inhabit South Africa and are not important for our purpose.

FAMILY.—*Hyænidæ.*

The *Hyænidæ* alone of all Carnivora have four toes on both pairs of feet, the muzzle is rounded, the tongue rough, and the hind-legs are

shorter than the fore-legs, the claws being non-retractile. The common Striped Hyæna (fig. 410) of India can be recognised by the prominence of the bony crest in front of the head and its relatively short hind-legs.

CYNOIDEA.

FAMILY.—*Canidæ.*

The Canidæ are the only family to be considered in this group. The family comprises the dog, wolf, fox, jackal, etc. The animals have pointed muzzles, smooth tongues, and non-retractile claws. The fore-feet have five toes each, the hind-feet four only, and this is the case with all the Indian wild species. There are four premolars and two molars above. Wild dogs and wolves are destructive to Indian game animals, and foxes commit depredations on poultry, etc. Fig. 411 shows the skull of *Vulpes bengalensis*, the Indian fox. Jackals are omnivorous and do a good deal of damage at times by feeding upon sugar-cane. They also eat coffee-berries and thus aid largely in the distribution of the plant, as the seeds pass through the digestive organs without injury.

ARCTOIDEA.

Animals which apply the whole or the greater part of the sole to the ground. In most instances, the portion of the sole employed is hairless.

FAMILY.—*Mustelidæ.*

The *Mustelidæ* include the Martens, Polecats, Stoats, Weasels, Badger, Otters, etc., and have short legs and elongated worm-like bodies and a stealthy, gliding mode of progression. The Otters live in water and have webbed feet. The skins of many of the animals of this family are valuable owing to the furs with which they are covered. *Mustela flavigula* (fig. 412) is the Indian Marten, common in the Himalayas and hilly parts of Burma.

FAMILY.—*Procyonidæ.*

The *Procyonidæ* or Racoons are chiefly natives of Tropical and South America. The single Indian genus *Æleurus* contains one

Fig. 407.

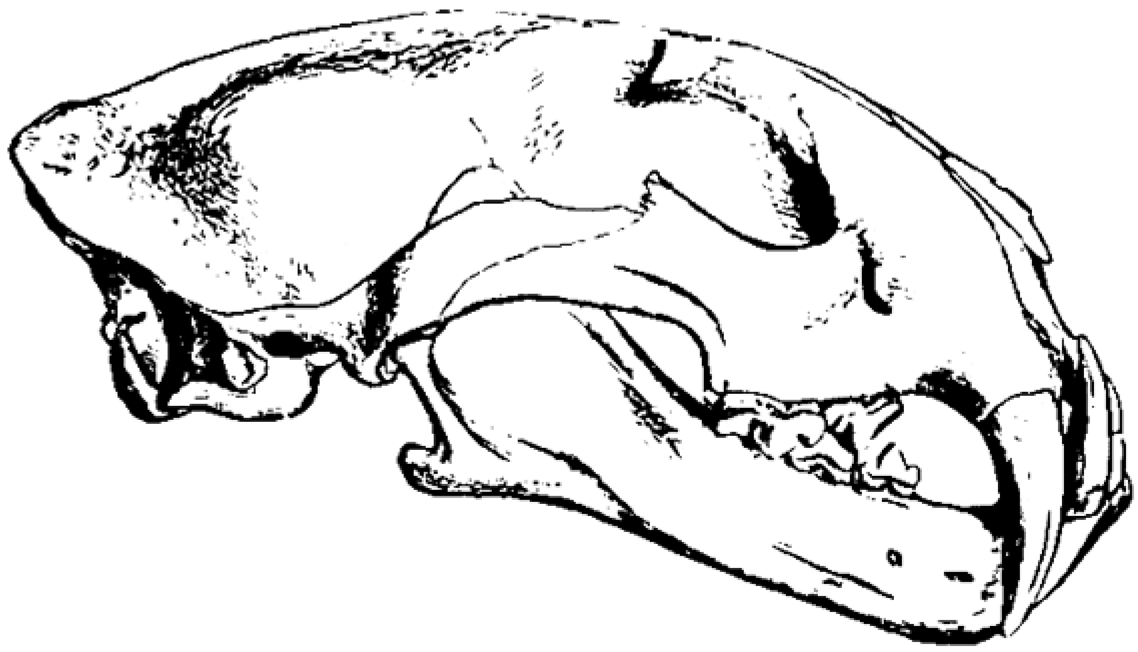


Fig. 408.

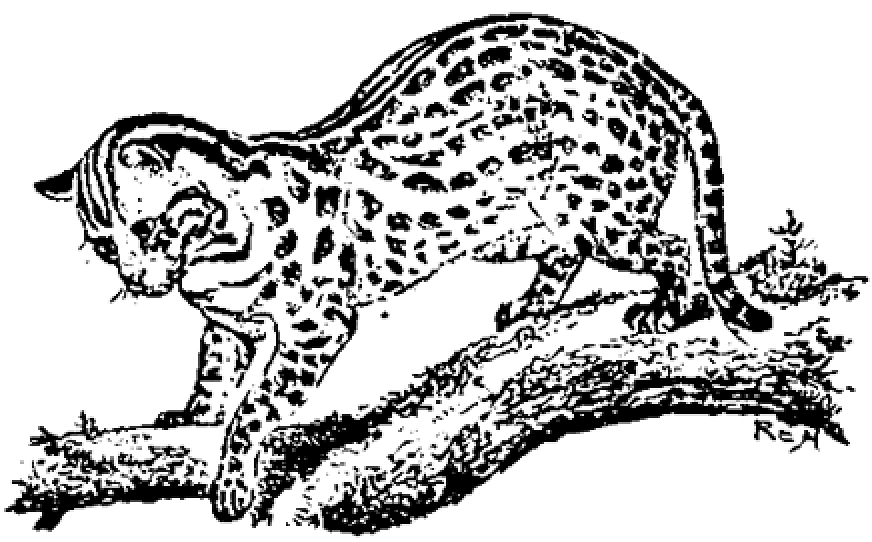


Fig. 409.

407. Skull of the Clouded Leopard (*Felis nebulosa*).
408. The Leopard Cat (*Felis bengalensis*).
409. The large Indian Civst (*Viverra zibetha*)

Fig. 410.

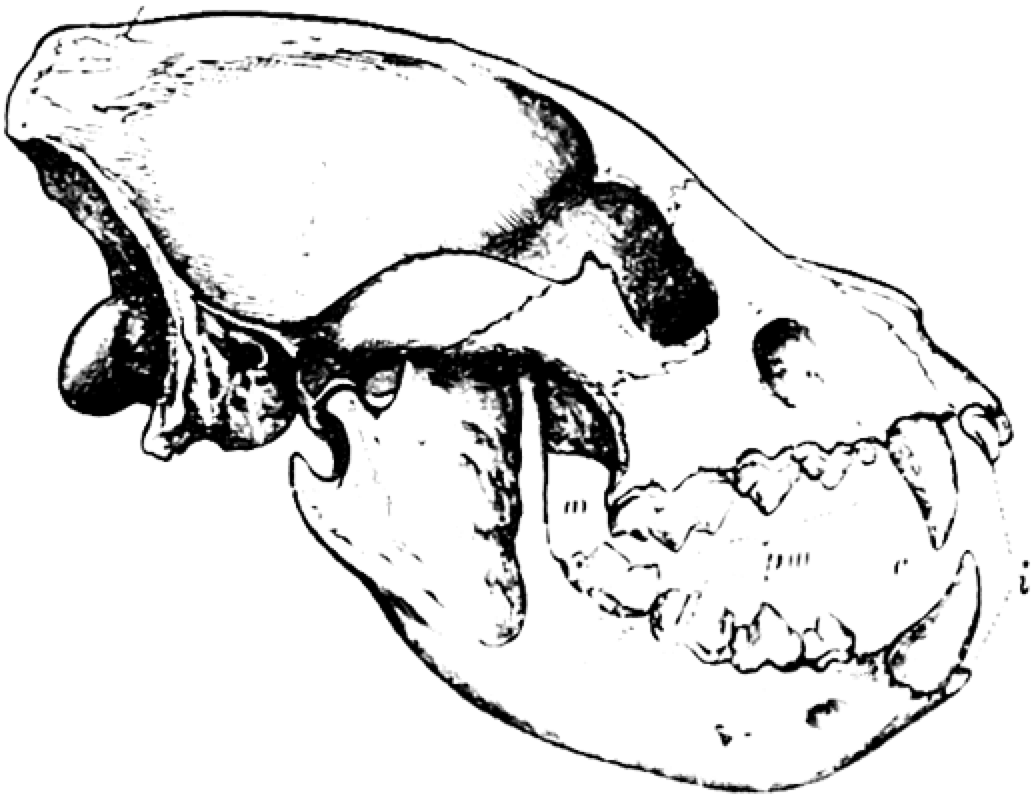
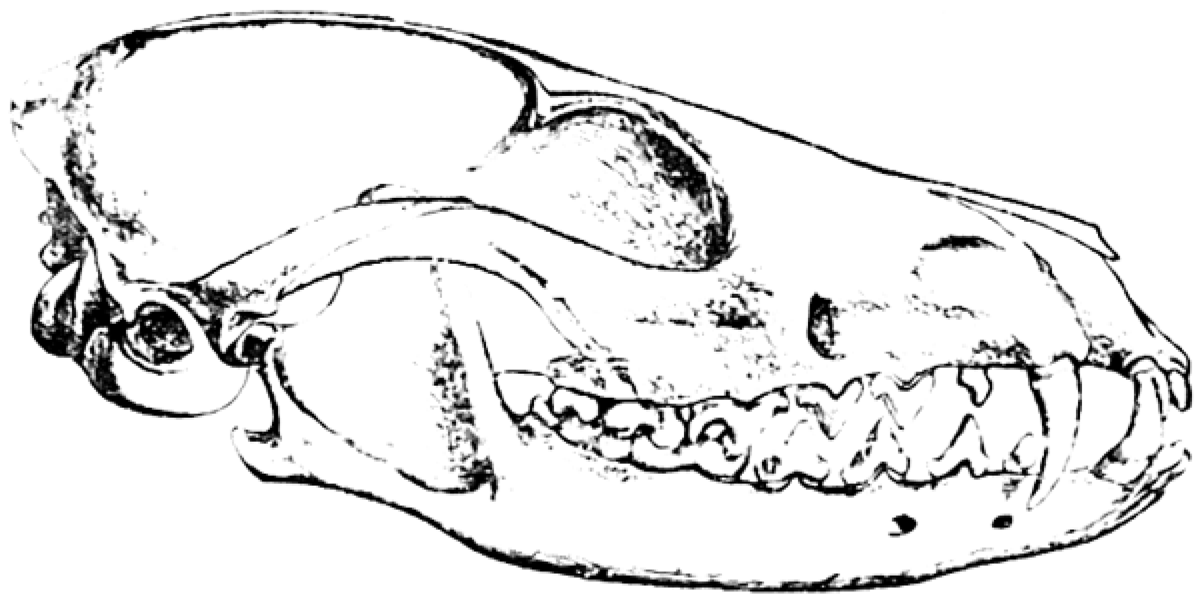


Fig. 411.



410. SKULL OF THE STRIPED HYÆNA (*Hyæna striata*).
411. SKULL OF THE INDIAN FOX (*Vulpes bengalensis*).

species, *Æ. fulgens*, the red cat-bear or Himalayan racoon, an inhabitant of the South-Eastern Himalayas. It inhabits forests, living in holes in trees. It is to be found feeding both on the ground and in trees. Fig. 413 shows this animal.

FAMILY.—*Ursidæ*.

The *Ursidæ* include the bears. The portion of the foot applied to the ground in walking by the bears is nearly or altogether destitute of hairs, except in the White Bear of the Arctic Regions. This White Bear and the Common Brown Bear (*Ursus arctus*) are the most typical examples of the *Ursidæ*. The bears are much less purely carnivorous than the majority of the order, and in accordance with their omnivorous habits the teeth do not exhibit the typical carnivorous characters. The incisors and canines have their usual carnivorous form, but the hinder premolars and the molars are furnished with broad tubercular crowns. The claws are large, curved, and strong, but are not retractile. The tongue is smooth, the ears small and erect, the tail short, and the nose mobile. Most of the bears are only carnivorous in that they eat flesh when they can get it; but a great part of their food consists of roots, fruits, seeds, honey, and even insects. Fig. 414 shows the skull of *Melursus ursinus*, the Sloth-bear or Indian Bear. This animal has small teeth and is rarely, if ever, carnivorous.

They occasionally do damage by barking trees. In the Jaunsar Division in the North-Western Himalayas the bear has a habit of barking and girdling the deodar; quite a number of trees are killed off in this way.

ORDER 9.—INSECTIVORA.

This order comprises a number of small animals, very similar in many respects to the Rodents, but they have not the peculiar incisors of that order, and they are provided with clavicles. All the three kinds of teeth are present, but the dentition varies, and the only common character is that the crowns of the molar teeth are furnished with small pointed eminences adapted for crushing insects, which form the chief food of the order. This is shown in Fig. 415, which depicts the skull of *Tupaia ferruginea*, the Malay Tree-shrew. All the toes have claws; there are usually five toes to each foot, and most walk upon the

soles of the feet. They are very small animals and exist over the whole world, except in Australia and South America, where their place is taken by Marsupials, such as the Opossums.

The order is divided into several families, of which the following occur in India :—

FAMILY.—*Tupaiidæ.*

The *Tapaiidæ* or Tree-shrews closely resemble squirrels in general appearance, and, like squirrels, live in trees and are diurnal in their habits. They have well-developed limbs, sharp claws, and a bushy tail. Species occur in India and Burma and in other parts of the Oriental region.

FAMILIES.— *Erinaceæ* (Hedgehogs) and *Talpidæ* (Moles).

The *Erinaceæ* include the Hedgehogs, which have the power of rolling themselves into a ball on the approach of danger. The hedgehogs have the back and sides covered with spines. Very little is known about the Indian species. It probably resembles its European confrère and lives upon insects, worms, snails, slugs, mice, rats, etc.

The *Talpidæ* or Moles are distinguished by having the body covered with hair, the feet short, and formed for digging, and the toes furnished with strong curved claws. There is no external ear, and the eyes are either extremely small or are completely concealed beneath the skin. They are all nocturnal burrowing animals and damage roots in their tunnelling operations.

Two or three species inhabit the Himalayas, Assam, and Burma. *Talpa micrura* (fig. 416) is the mole of Nepal, Sikkim, and hills south of Assam. It is common round Darjeeling.

FAMILY.—*Soricidæ* (Shrews).

The *Soricidæ* or Shrews are very like true mice in external appearance, but they are really widely different. The body is covered with hair, the feet are not adapted for digging, and the external ears are thin, the eyes being well developed. The *Soricidæ* probably contain the smallest of existing mammals, a shrew which does not exceed,

Fig. 412.

Fig. 413.

412. THE INDIAN MARTEN (*Mustela flavigula*).
413. THE RED CAT-BEAR (*Ælurus fulgens*)

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Fig. 414.

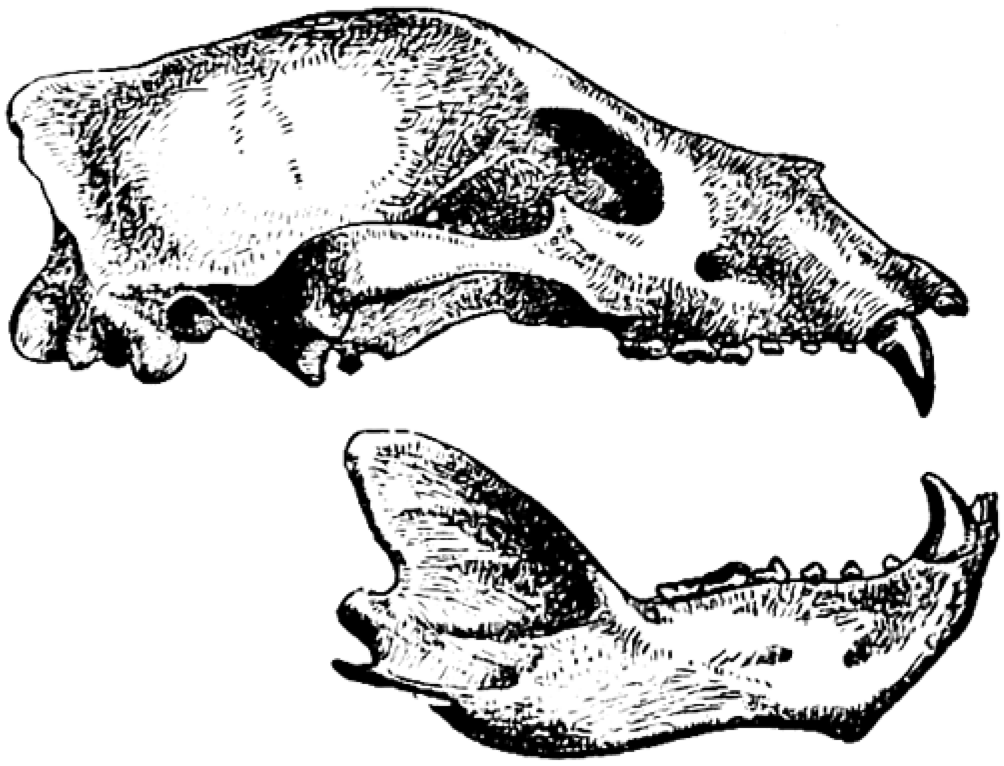

Fig. 415.

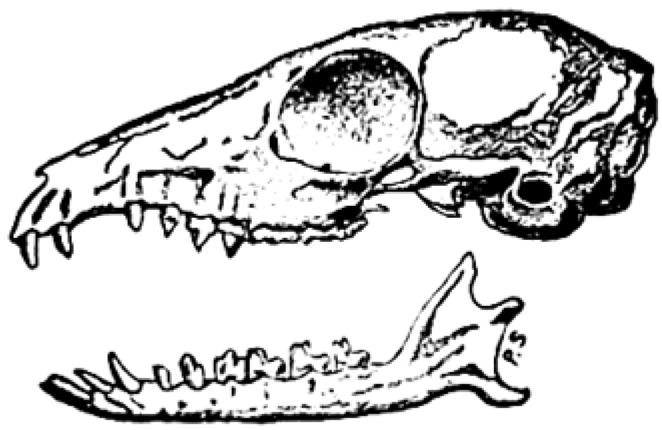

Fig. 416.

414. SKULL OF THE INDIAN BEAR OR SLOTH-BEAR (*Melursus ursinus*).
415. SKULL OF THE MALAY TREE-SHREW (*Tupaia ferruginea*).
416 THE SHORT-TAILED MOLE (*Talpa micruro*).

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including the tail, 2½ inches in length. A common Indian example is *Crocidura murina* (fig. 417), the brown musk shrew or musk rat found all over India.

FAMILY.—*Galeopithecidæ.*

The *Galeopithecidæ* or Flying Lemurs possess a flying membrane extending as a broad expansion from the side of the neck to the arms, from the arms to the hind-legs, and from the hind-legs to the tail. The animal with this takes extensive leaps from tree to tree. More than one species is known to inhabit the Indian Archipelago, and they feed on insects and small mammals. *Galeopithecus volans*, the flying lemur (fig. 418), is found in Tenasserim.

ORDER 10.—CHIROPTERA (Bats).

This order is one of the most distinct amongst the Mammalia and comprises only the bats. The fore-limbs are much longer than the hind-limbs and have several of the fingers enormously elongated. These long fingers are united by a leathery membrane which not only stretches between the fingers, but is also often extended between the fore and hind-limbs, and is attached to the sides of the body, and often includes the tail. The membrane is nearly or quite naked or destitute of hairs on both sides. It is used as an organ of true flight and in accordance with these there are well-developed collar-bones, (clavicles), and the breast-bone is furnished with a ridge for the attachment of the pectoral muscles. The mammary glands are placed upon the chest. Teeth of three kinds are always present, and the canines are always well developed.

The bats are twilight-loving or nocturnal animals, and they are the only mammals which possess the power of true flight. The eyes are small, but the ears are very large, and the sense of touch is most acute. During the day they retire to caves or crevices in rocks or the roofs of houses, hollow trees, etc., where they suspend themselves by the hind-feet, which are provided with curved claws. The body is covered with hairs, and the tail may be long or short. Their flight is not as rapid as that of birds. Most bats hibernate.

They are divided into the Insectivorous and Frugivorous Bats. The Insectivorous bats are small, and all live upon insects and so are useful to the forester. The Vampire Bats, which suck the blood

of sleeping animals, are also included here. The fruit-eating bats include the well-known so-called Indian flying-fox (*Pteropus medius*), of which fig. 419 shows the skull, which feeds upon fruit and does a large amount of damage by feeding in mango and other orchards. They are probably of some use in distributing seeds.

Fig. 420 shows the grizzled bat, *Vesperugo mordax*.

ORDER II.—PRIMATES.

This order includes, Lemurs, Monkeys, and Man, which have the same *anatomical* characters. The Primates may be defined as possessing perfect clavicles which articulate with the top of the sternum. The radius and ulna and tibia and fibula are complete. The typical dental formula is—

$$i.\ \frac{2-2}{2-2};\ c.\ \frac{1-1}{1-1};\ pm.\ \frac{2-2}{2-2}\ \text{or}\ \frac{3-3}{3-3};\ m.\ \frac{3-3}{3-3}\ =\ 32\ \text{or}\ 36$$

In no instance are there more than 36 teeth altogether, and the molars always have broad and tuberculate crowns. The mammary glands are typically two in number, and are almost always pectoral in position. The eyes are enclosed in distinct sockets.

The monkeys are often a source of annoyance to the forester and occasionally do a considerable amount of damage in nurseries by uprooting seedlings, etc., and turning up the soft earth of the seed beds to hunt for seeds.

FAMILY.—*Lemuridæ*.

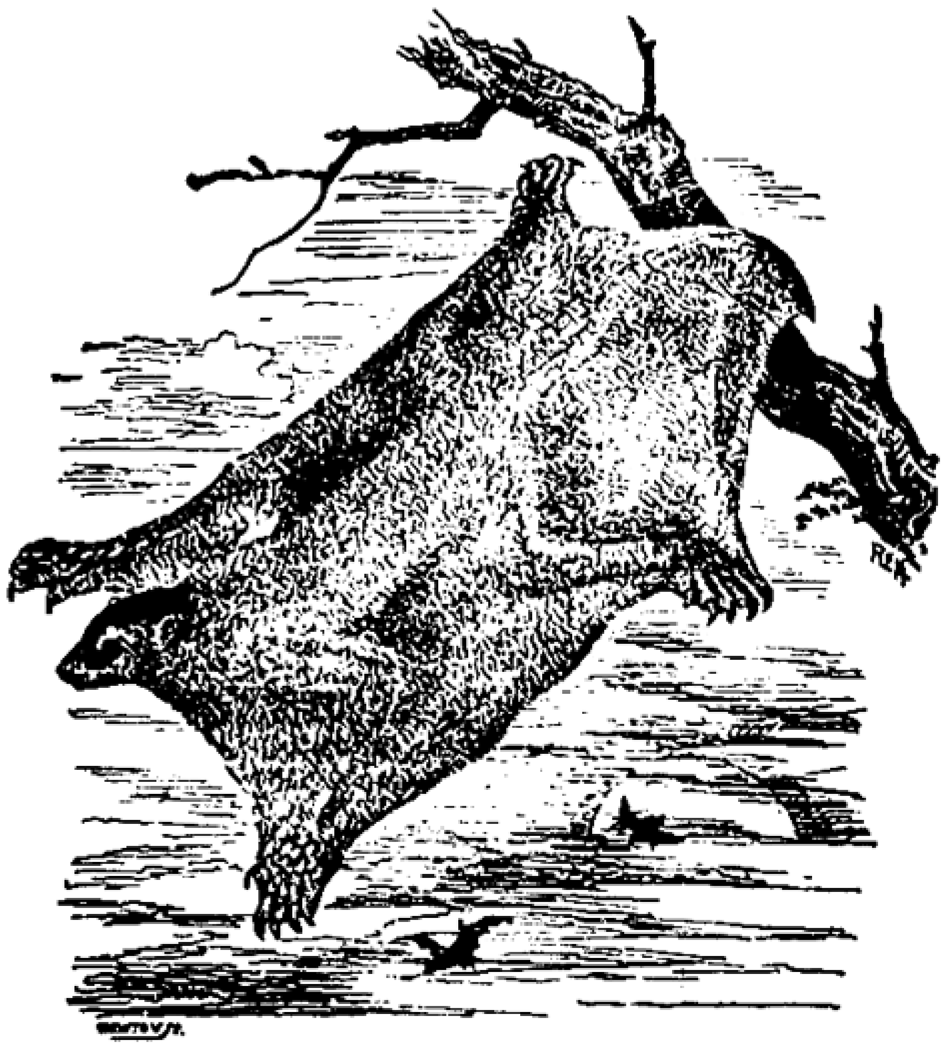
The Lemurs differ so much from monkeys that they are often arranged in a distinct order. They have longer heads with a narrow muzzle, differently-shaped teeth, and a peculiar claw-like nail on the second digit of the foot. Two species occur in India, one in Burma, and another, *Loris gracilis*, in Southern India and Ceylon.

FAMILY.—*Cercopithecidæ*.

Comprises the Apes, Monkeys, and Baboons. Monkeys with tails Includes two sub-families.

Fig. 417.

Fig 418.



417. THE BROWN MUSK SHREW (*Crocidura murina*).
418. THE FLYING LEMUR (*Galeopithecus volans*).

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Fig. 419.

Fig. 420.

Fig. 421.

419. Skull of the Flying-Fox or Indian Fruit Bat (*Pteropus medius*).
420. The Grizzled Bat (*Vesperugo mordax*).
421. Skull of the Langur or Hanuman Monkey (*Semnopithecus entellus*).

Fig. 422.

422. THE WHITE-HANDED GIBBON (*Hylobates lar*).

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SUB-FAMILY.—*Semnopithecinæ.*

Slender monkeys with long tails and no cheek pouches. Their food consists chiefly of leaves and young shoots. *Semnopithecus entellus*, the Lungoor or Hanuman Monkey, of which fig. 421 shows the skull, is the common sacred monkey of Northern India. It feeds upon fruit, grain, seedpods, leaves, and young shoots. It has a loud voice which is often heard.

SUB-FAMILY.—*Cercopithecinæ.*

The tail is variable in length, and cheek pouches are present. *Macacus rhesus* is the common Bengal monkey, which is never molested and is as impudent as the lungoor.

FAMILY.—*Simiidæ.*

The *Simiidæ* in which no tail is developed. This family contains the howling hoolock (Gibbon) monkeys of the jungles of Bengal, Assam, and Burma. It also includes the Gorilla, Chimpanzee, and Orang Outang. The Gibbons, *Hylobates*, inhabit Asia. Fig. 422 shows *Hylobates lar*, the white-headed Gibbon.

FAMILY.—*Hominidæ* (Man).

In man the hind-limbs are developed so as to support the body without the assistance from the fore-limbs, and are extremely muscular.

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